AD-A148 318 INSTALLATION RESTORATINN PROGRAM PHASE II STAGE 1 1/3
PROBLEM CONFIRMATION STUDY DULUTH INTERNATIONAL AIRPORT
DULUTH MINNESOTA(U) WESTON (ROY F) INC WEST CHESTER PA
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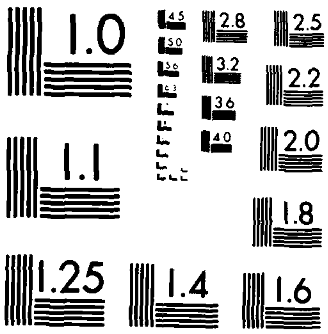

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Installation Restoration Program

Final Report
Phase II Stage 1
Problem Confirmation Study
Duluth International Airport
Duluth, Minnesota

Prepared For:

United States Air Force
Occupational and Environmental Health Laboratory (OEHL)
Brooks Air Force Base, Texas

October 1984

WESTON
DESIGNERS CONSULTANTS

Notice

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EXECUTIVE SUMMARY

Introduction

Roy F. Weston, Inc. (WESTON) was retained by the U.S. Air Force Occupational and Environmental Health Laboratory (OEHL) under Contract No. F33615-80-D-4006 to provide general engineering, hydrogeological and analytical services. These services were applied to the Installation Restoration Program (IRP) Phase II effort at Duluth International Airport (DIAP) under Task Order 0025 of this contract.

In 1976 the Department of Defense (DoD) devised a comprehensive IRP. The purpose of the IRP is to assess and control hazardous environmental contamination that may have resulted from past operations. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June, 1980 (DEQPPM 80-6), requiring identification of past hazardous waste disposal sites on DoD agency installations. The U.S. Air Force implemented DEQPPM 80-6 by message in December, 1980. The program was revised by DEQPPM 81-5 (11 December 1981) which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 by message on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

Only the Phase II Problem Confirmation portion of the IRP effort at Duluth International Airport was part of this task order.

Scope of Work

Duluth International Airport is a Tactical Air Command (TAC) Installation located approximately 7 miles northwest of the City of Duluth, at the western end of Lake Superior. Field operations under Task Order 0025 were limited to the four sites shown on Figure S-1: the Goose Missile Site Disposal Area; the Fire Training Areas FT-1 and FT-2; the DPDO

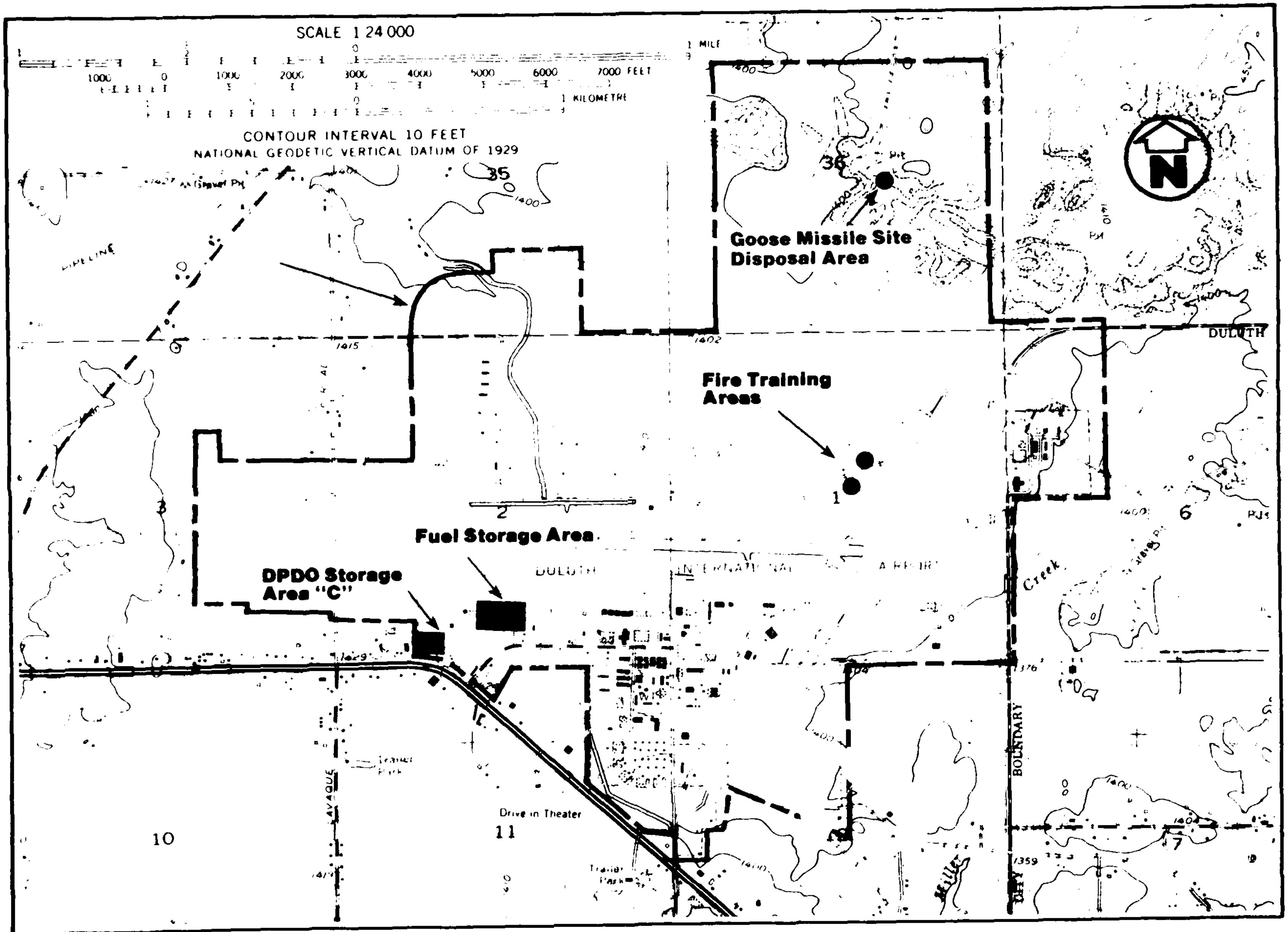

FIGURE S-1 LOCATIONS OF PHASE II SITES

Storage Area "C", and the Fuel Storage Area. Surface water and 11 sediment samples were taken at the Goose Missile Site Disposal Area pond. Soil samples for chemical analyses were taken from 10 borings and 2 drainageway locations at the DPDO Storage Area "C". Twenty investigative soil borings and two test pits were placed in the Fuel Storage Area. A total of 11 groundwater monitoring wells were completed in the glacial drift water table aquifer: 7 in the Fire Training Area and 4 in the Fuel Storage Area. All wells were surveyed for elevation and groundwater surface contour maps were developed for the 2 sites. One round of water samples was obtained for chemical analyses from each well, 1 test pit and 2 stream locations. All water quality analyses were performed in WESTON's laboratory in accordance with USEPA Standard Methods. All data were analyzed to produce an assessment of groundwater, surface water and soil contamination at each of the 4 sites.

Major Findings

Based on the analyses performed, levels of contamination were found in soils, groundwater and surface water that warrant concern and possible future action.

The most common contaminant noted is oil and grease which exceeded the aesthetic criterion of 0.01 mg/l (USEPA, 1976) in all monitor well and surface water samples analyzed for that parameter. Only one surface water sample at the Goose Missile Site Disposal Area exceeded the fresh water aquatic life guideline for the pesticide DDD, and this sample was obtained in close proximity to a barrel of unknown contents.

The major potential problem indicated by the data available is that of halogenated organic compounds (TOX) detected in the Fire Training Area monitoring wells. All groundwater samples tested for TOX contained concentrations in excess of 15 parts per billion (ppb) and 2 wells exceeded 100 ppb. Specific halogenated organic compounds should be identified during IRP Phase II, Stage 2 work, since standards exist or are proposed for some of these compounds. Specific halogenated organic compounds should also be identified at the Goose Missile Site, since TOX values over 29 ppb were detected.

The DDD pesticide levels in bottom sediments from the Goose Missile Site Disposal Area are not viewed by WESTON as an indicator of a major environmental problem--DDD has a very low aqueous solubility, and available data indicate that DDD compounds are exiting the disposal site at very low concentra-

tions, if at all. However, the presence of non-pesticide organics peaks in gas chromatograms from those same soils, tentatively identified as PCB Arochlor 1260, is cause for concern. USEPA and State soil guidelines concerning PCB are in a constant state of adjustment, and guidelines are currently under consideration which may require cleanup of all soils contaminated with PCB at a level exceeding one milligram per kilogram (1 part per million). Bottom sediments at the Goose Missile Site Disposal Area should be resampled to verify and quantify the tentative identification of these peaks as PCB compounds.

Soils at the DPDO Storage Area "C" were shown to be contaminated with oil and grease compounds and a selection of VOA compounds from the USEPA Priority Pollutant List. While soil concentrations were relatively low, a potential for groundwater contamination exists. Monitoring wells are recommended in Stage 2 to evaluate this potential.

Conclusions

Based upon the results of the Phase II Confirmation Study at DIAP, the following key conclusions have been drawn:

1. Groundwater occurs under shallow water table conditions in and around all sites investigated. Lateral groundwater gradients typically average about 0.02. While the hydraulic driving force for groundwater contaminant migration is fairly large, due to this relatively high gradient, the actual rate of movement of groundwater is slow (on the order of 10 feet per year) due to the presence of low-permeability glacial till.

2. Regional water table flow is generally northerly, as determined at the Fire Training Areas and the Fuel Storage Area. Locally, however, this regional gradient is modified by surface drainageways which intercept the upper few feet of water table flow. Discharge of shallow groundwater to these surface drainageways creates a potential for off-base migration of contaminants.

3. The potential for off-base migration of contaminants is demonstrated by detection of solvent compounds in the surface drainageway adjacent to the DPDO Storage Area "C" and by observation of oily

discharges in surface drainageways adjacent to the Fuel Storage Area.

4) Part-per-billion level concentrations of the pesticide DDD were found in the bottom sediments of the Goose Missile Site Disposal Area. However, off-site migration of pesticides in water or sediments appears to be negligible. A non-pesticide compound, tentatively identified as PCB, was detected in Goose Missile Site Disposal Area sediments in the same general distribution as the pesticide. The identification of the compound should be confirmed.

5. The groundwater flow direction across the Fire Training Areas is to the north at a rate estimated to be on the order of 10 feet/year towards surface drainage areas associated with Wild Rice Lake. Based upon topography, it is likely that a groundwater divide exists to the south of the well network, in the direction of the runway. Elevated concentrations of TOC, TOX, and oils and grease were found in all seven wells. The distribution of contaminant levels reflects the dispersed nature of contaminated soils which are affecting groundwater quality. Although the extent of soil contamination of the FT-1 site is unknown, its boundary probably extends beyond the area outlined by the well network including MW-4 through MW-7. Migration of contaminants from both Fire Training Areas in the groundwater toward the north will enter the drainage system associated with Wild Rice Lake.

6. There is contamination of soils on the DPDO Storage Area "C" by oil and grease and by volatile organic compounds. This contamination extends at least two feet deep at the site and is distributed throughout the site. In two soil samples in the drainageway, levels of oil and grease and volatile organic compounds were found comparable to levels in on-site soils. This may indicate that off-site erosion of contaminated soils is occurring or that direct spillage to the ditch has occured. There is also a potential for contaminants to dissolve and to migrate to the water table and then to surface drainageways which flow to Beaver Creek, a tributary to Wild Rice Lake.

7. Free-floating fuel oil is abundant in the soil and on the water table in the immediate vicinity of the Fuel Storage Area, as documented during exploratory soil drilling in the area. The source of the contamination is likely to be leakage from the storage tanks and transmission lines over the history of the facility. The groundwater surface around the entire site is intercepted by surface drainageways or buried culverts which act as discharge lines for the upper several feet of the groundwater table and contaminants that may be floating on it. Oily products in the groundwater are entering the surface drainage system adjacent to the site, and then discharging directly to Beaver Creek. Although the extent of contamination in the groundwater around the fuel storage area is limited in area, an immediate avenue is available for discharge of contaminants into surface drainageways and migration off-site.

8. Two sites not included in the Phase 2 study were identified during this study, and they warrant attention during Stage 2. They include a fuel loading dock area, located south of the Fuel Storage Area (Site SP-1) and the Old DPDO Storage Area (Site S-1). A buried fuel line runs from the pump house in the tank farm to the loading dock area. According to site personnel, the line may contain fuel, although it is not in use. Recommendations have been made for the evaluation of these two sites during Stage 2 work.

Recommendations

WESTON has recommended that the Phase II IRP study at Duluth International Airport be continued with a Stage 2 effort. The recommendations are summarized, site-by-site, in Table S-1.

Table S-1

RECOMMENDED QUANTIFICATION STAGE ACTIONS

Site	Recommended Action	Rationale
Goose Missile Site Disposal Area Pond	Collection of 8 additional pond bottom sediment samples for analysis of pesticides and PCB's	Evaluation of the extent of pesticide concentrations where previous high levels were found and verification of the presence of PCB contamination
Fire Training Areas	Resampling 7 existing monitoring wells for analytes previously sampled	Verification of initial analyses
	Additional sampling of MW-2 for USEPA Priority Pollutant Volatile Organic Compounds (VOA)	To establish specific parameters of concern
	19 soil borings	Establish extent of soil contamination and identify boundary of FT-1
	Installation of additional monitoring wells	Identify extent of off-site migration of contaminants in groundwater
	Sampling of drainageway water and soils	Identify extent of off-site migration of contaminants in surface water and eroded soils
	Analysis of soils and water samples according to protocol established by initial re-sampling of existing wells	Identify magnitude and extent of soil and groundwater contamination
DPDO Area "C"	Analyses of soils already collected at boring intervals of 3 to 5 feet	Determine the depth of contaminants in the soil
	Collection and analyses of 3 additional soil samples in the drainageway for oil and grease and for USEPA Priority Pollutant Volatile Organic Compounds	Determine the extent of off-site migration of contaminated soils by erosion
	Installation of a single groundwater monitoring well within the site and analysis of ground-water and soil samples for USEPA Priority Pollutant Volatile Organic Compounds (VOA)	Identify possible contaminant migration from the site to the ground water table
Fuel Storage Area	Resample existing wells for same analytes previously sampled plus USEPA Priority Pollutant Volatile Organic Compounds (VOA)	Verify initial results and identify specific contaminant compounds
	Geophysical survey of subsurface	To locate precisely, buried facilities that may contribute to contaminant sources or migration
	12 additional soil borings and 4 test pits. Installation of groundwater monitoring points at 4 boring locations	Identify the extent of free-floating fuel contaminantion in groundwater and soils
Fuel Loading Facility	6 soil borings and analysis of samples for oil and grease	Confirmation of possible contamination in this area
DPDO Storage Area S-1	10 soil borings with sampling and analysis of soils for oil and grease and USEPA Priority Pollutant Volatile Organic Compounds	Determine if contamination of of soils has occurred in these areas due to past storage practices

SECTION 1

INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM

In 1976 the Department of Defense (DoD) devised a comprehensive Installation Restoration Program (IRP). The purpose of the IRP is to assess and control migration of environmental contamination that may have resulted from past operations and disposal practices on DoD facilities, and probable migration of hazardous contaminants. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA, or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June, 1980 (DEQPPM 80-6), requiring identification of past hazardous waste disposal sites on DoD agency installations. The U.S. Air Force implemented DEQPPM 80-6 by message in December, 1980. The program was revised by DEQPPM 81-5 (11 December 1981) which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 by message on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

1.2 PROGRAM HISTORY AT DULUTH INTERNATIONAL AIRPORT

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (OEHL) under a Contract Number F33615-80-D-4006, to provide general engineering, hydrogeological and analytical services. The Phase I, Problem Identification/Records Search for Duluth International Airport (DIAP) was accomplished by Engineering-Science Inc. in early 1982, and their Final Report was dated March, 1982. In response to the findings contained in the Phase I Final Report, the OEHL issued Task Order 0012 to WESTON, directing that a pre-survey site inspection be conducted at DIAP. The purpose of this pre-survey was to obtain sufficient information to develop a work scope and cost estimate for the conduct of a Phase II, Problem Confirmation Study at DIAP.

The Pre-Survey report for DIAP was submitted by WESTON in December, 1982. On 12 September 1983, Task Order 0025 was issued, authorizing a Phase II Study for four sites at DIAP. A copy of the formal task order is included here as Appendix B.

On 17 October 1983 WESTON met with representatives of the caretaker force at DIAP, and the drilling subcontractor (Soil Exploration Co., Inc.) to review the goals of the investigation, review drilling procedures and locations, and to establish the field schedule. Soil borings and monitoring well construction commenced on 25 October 1983 and were completed by 29 October. Groundwater and surface sediment sampling was completed during the weeks of 15 November 1983, and 2 January 1984.

1.3 BASE PROFILE

Duluth International Airport (DIAP) as a Tactical Air Command (TAC) installation encompassing 1,995 acres of land located approximately seven miles northwest of the City of Duluth, Minnesota, at the western end of Lake Superior. Figure 1-1 is an index map showing the location of DIAP. Since its inception in 1948, DIAP has hosted a variety of operational Air Force activities, and has been jointly operated by the Air Force, the Minnesota Air National Guard (ANG) and the City of Duluth. In December 1981, all Air Force operational missions at DIAP were terminated, and only a caretaker force presently remains on-site, pending disposition of Air Force interests in the site. ANG activities and commercial civilian activities are expected to continue at DIAP indefinitely. In November, 1983, the housing area on the southern side of the base was converted to a minimum security Federal prison.

Past Air Force activities at DIAP in support of operational missions have resulted in several waste disposal sites of potential concern. Each of these sites was rated by Engineering-Sciences Inc. during Phase I activities in accordance with the IRP Hazard Assessment Rating Method (HARM). The HARM system is a ranking model which considers four major factors: 1) receptors; 2) waste and its characteristics; 3) potential pathways for contaminant migration; and 4) past efforts at containing contamination. Under Phase I all sites evaluated have a point ranking assigned under each major factor, and a numerical HARM score is computed. Ideally, each site is evaluated using HARM such that the potential for environmental contamination is evaluated using consistent criteria from site to site and from base to base.

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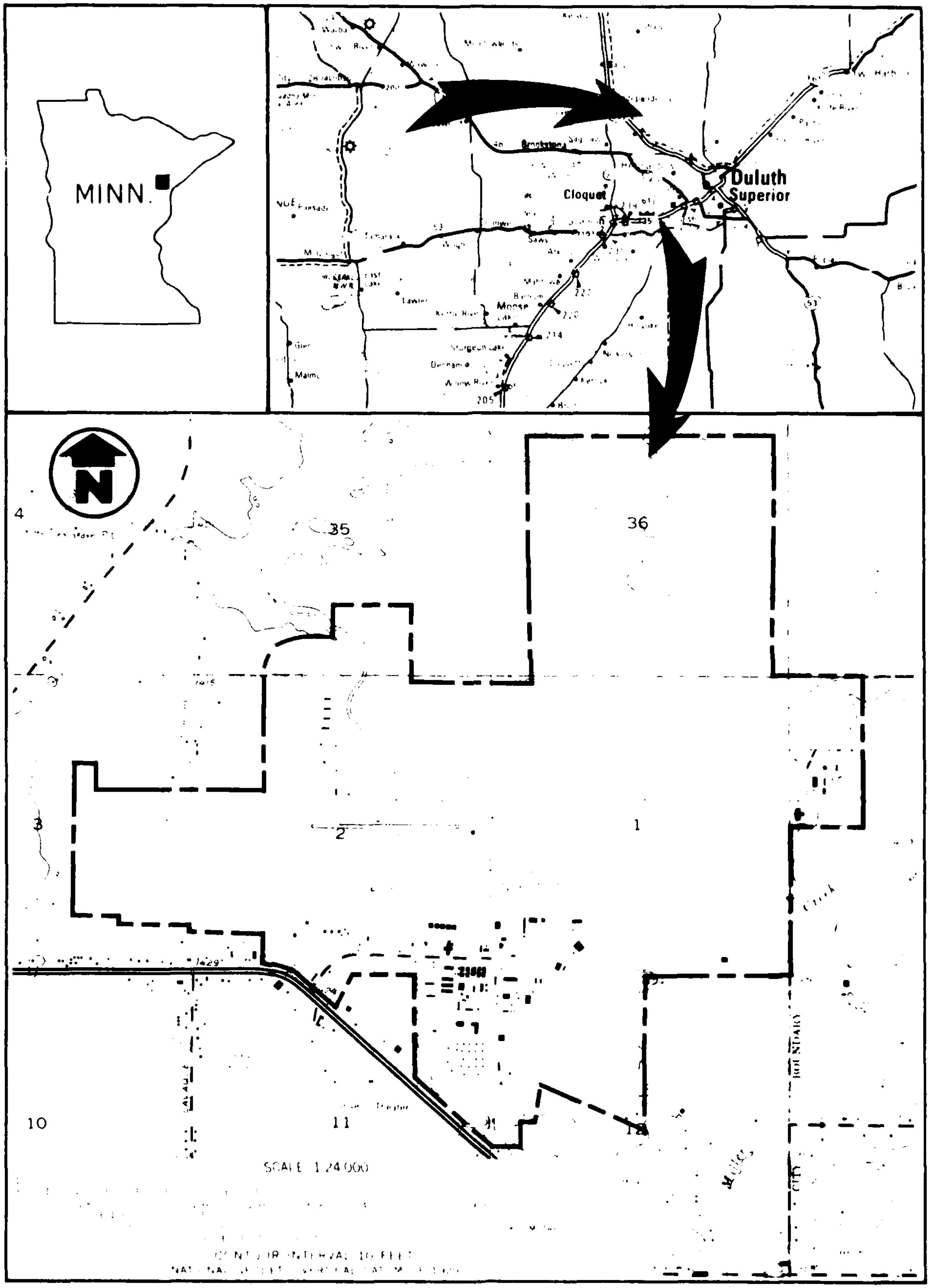

FIGURE 1-1 INDEX MAP SHOWING THE LOCATION OF DULUTH IAP

Based upon these HARM ratings and all other pertinent data, Engineering-Sciences Inc. recommended that Phase II activities concentrate on the sites ranked 1 through 5 in Table 1-1. Figure 1-2 shows the locations of all sites receiving HARM score rankings during Phase I activities. The following sections review each of the five sites identified for the Phase II scope of work.

1.3.1 Goose Missile Site Dump

The Goose Missile disposal site is located in a wetland depression to the north of the abandoned missile site, adjacent to and east of the access road, as shown on Figure 1-3. The area was a disposal site for barrels which may have contained pesticides. At the time of sampling, a number of barrels were visible along the perimeter of the pond and partially submerged in the pond. No markings were visible on the barrels at that time.

During our field investigation the entire site area was inundated by water, forming a small pond of approximately 6,000 square feet. The pond was roughly bell-shaped with two inlet channels at the north and east ends and one outlet channel at the south end. These channels were all dry during the field investigation. Since the inlets and outlets are approximately one foot higher than the pond level, the pond in fact acts as a sedimentation and runoff control basin. The pond outflow ditch leads to a larger dry ditch which did not have a well defined outlet. In general, the area drainage is not well developed, with numerous small ponds and bogs. Manmade disruption is evident from earth moving related to construction of the missile site and airfield. The West Duluth USGS 7.5 minute topographic quadrangle map of the United States Geological Survey (USGS) shows an extensive area around the Goose Missile Site that was disturbed by earth moving activities.

Although drainage from the disposal area pond is very poorly defined, the area lies less than 1 mile from Wild Rice Lake Reservoir and the general area drains in that direction. A manmade drainageway connecting the Goose Missile Site area to Wild Rice Lake is indicated on the USGS map 500 feet to the west of the disposal area, but there is no direct connection between the pond and this drainage way. Site drainage is discussed further in Section 2.3

TABLE 1-1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES*

DULUTH INTERNATIONAL AIRPORT

Rank	Site Name	HARM Score
1	Goose Missile Site Disposal Area (Site D-1)	64
2+	Fire Training Area (Site FT-2)	63
3+	Fire Training Area (Site FT-1)	56
4	DPDO Storage Area "C" (Site S-2)	55
5	Fuel Storage Area (Site SP-1)	53
6	South Goose Missile Site Dump (Site D-4)	50
7	Goose Missile Site Dump (Site D-2)	49
8	Runway 13 NE Disposal (Site D-6)	48
9	Old DPDO Storage Area (Site S-1)	48
10	Disposal Pit (Site D-9)	44
11	Low-Level Radioactive Waste Disposal (Site RD-1)	44

*From The Engineering - Science, Inc., Phase I Records Search Final Report.

+FT-1 and FT-2 are treated in the Phase II investigation as a single site.

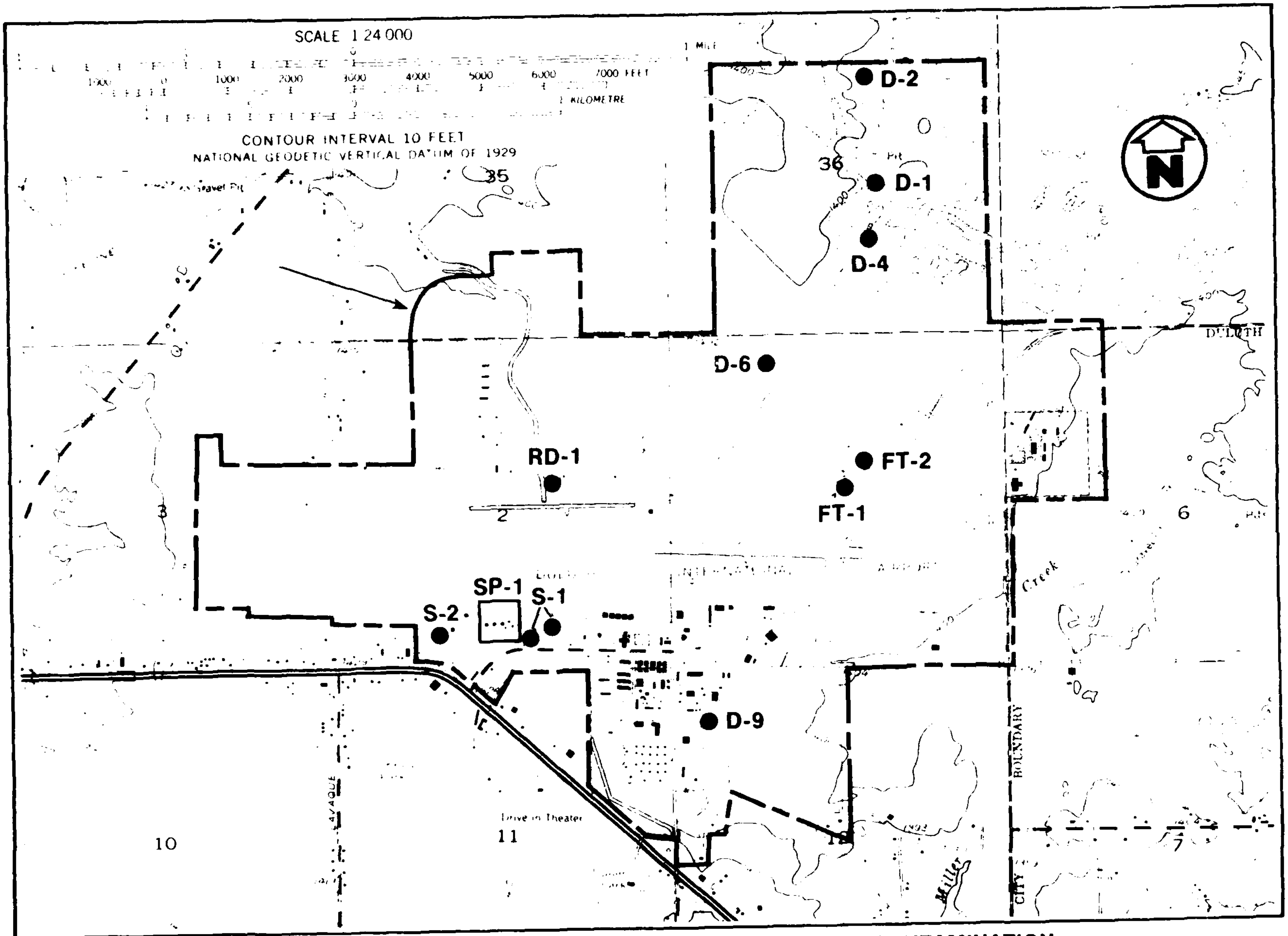

FIGURE 1-2 LOCATIONS OF ALL POTENTIAL SOURCES OF CONTAMINATION RECEIVING PHASE I HARM SCORE RANKINGS

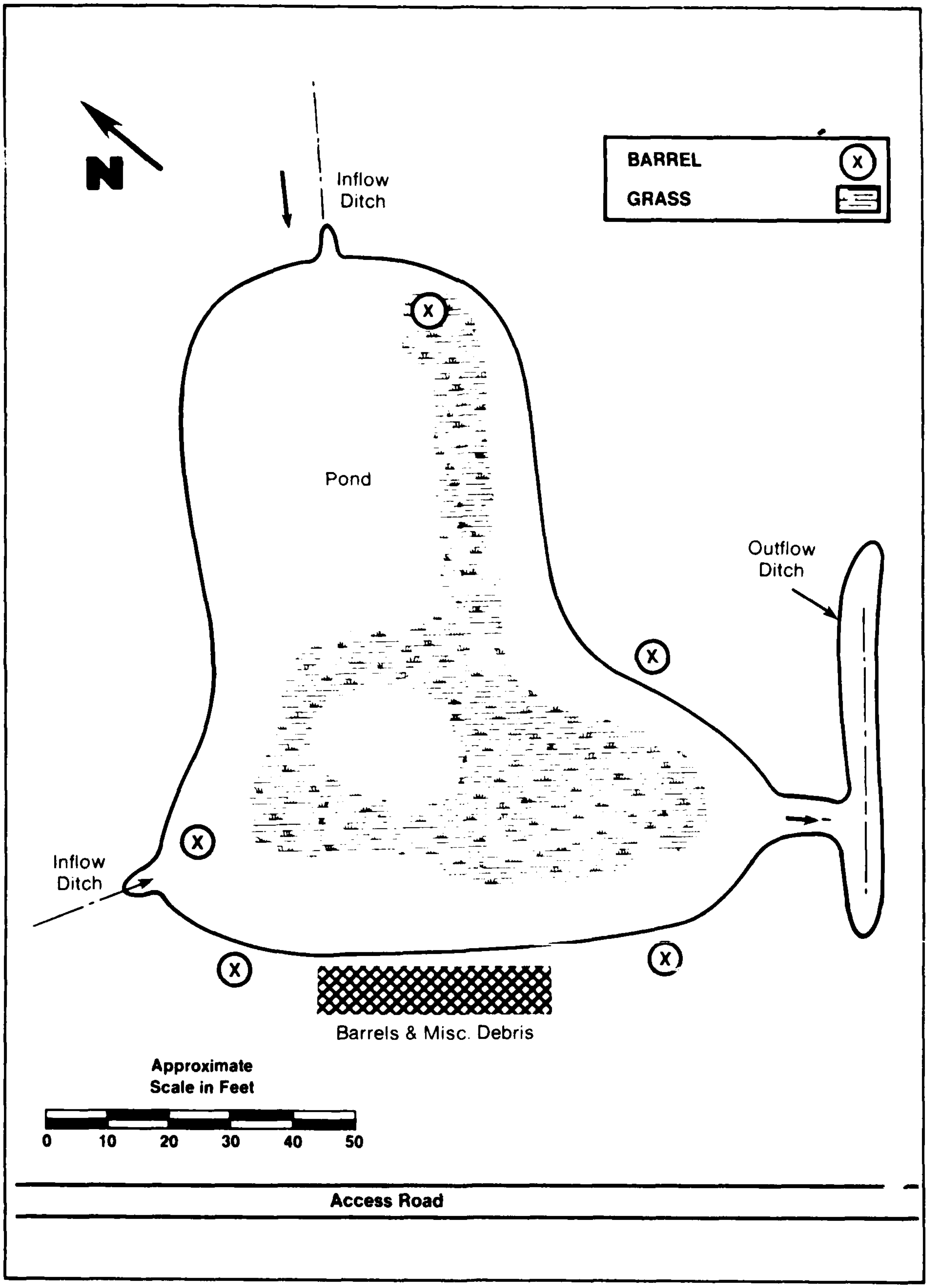

FIGURE 1-3 GENERAL SITE MAP FOR THE GOOSE MISSILE SITE DISPOSAL AREA

1.3.2 Fire Training Areas

Fire training activities have been conducted on two adjacent sites at Duluth airport, identified in the Phase I Report as FT-1 and FT-2. For purposes of this Phase II Confirmation Study these two areas have been considered as a single site. As shown on Figure 1-4, these sites are located to either side of the perimeter access road to the west of the northeast-southwest runway. Site FT-1 is no longer used, and surficial evidence of its exact boundaries has been obliterated by subsequent earth moving and filling. None of the available air photographs of the area showed the original FT-1 boundaries. Although Site FT-1 is at a slightly higher elevation than the surrounding ground, the area is poorly drained and much of the ground is normally saturated. The area slopes generally towards the airstrip to the south. Site FT-2 is the fire training area currently in use, is roughly circular, and is about 200 feet in diameter. In the center of the site is a mock airplane structure which is periodically doused with waste fuels and ignited for fire training exercises. The FT-2 area has an irregular surface which is periodically churned up by heavy equipment. Water ponding occurs in tire tracks and other ruts. Ponded water, particularly in the center of the site, was observed to contain oily products. Surface drainage from Site FT-2 is to the north, towards the marshlands bordering Wild Rice Lake. The area is located on an earth-filled pad that lies over northward sloping ground. A drainage ditch starting at the access road runs past the southwest boundary of the FT-2 area enroute to Wild Rice Lake.

1.3.3 Defense Property Disposal Office (DPDO) Storage Area "C"

DPDO Storage Area "C" is a small earth and gravel pad approximately 6,000 square feet in area, located in the southwest corner of DIAP, as shown on Figure 1-5. This pad has been used for temporary storage of drums of waste solvents and other materials pending disposal by DPDO. The pad is constructed entirely of soil and gravel materials raised approximately 5 feet above the surrounding ground and original grade. A drainage ditch runs from adjacent to the entrance ramp on the east and around to the north of the site. The site has no berm or liner and is unfenced. From 1965 to 1980 petroleum based waste liquids were stored in drums on the site. At present no materials are stored there. Although no major spills have been recorded at the site, evidence of accumulated spillage from small container

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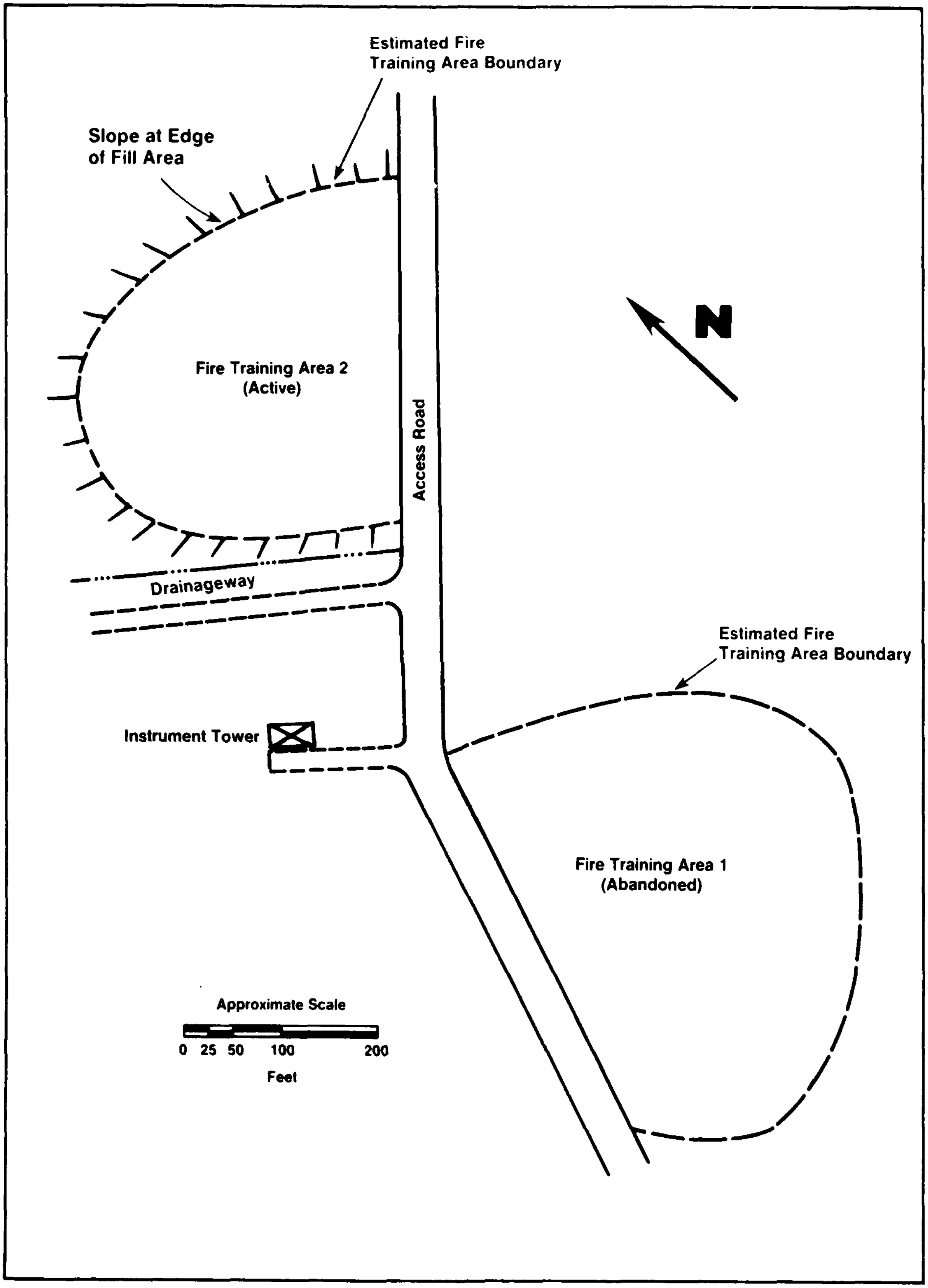

FIGURE 1-4 GENERAL SITE MAP FOR THE FIRE TRAINING AREAS, SITES FT-1 AND FT-2

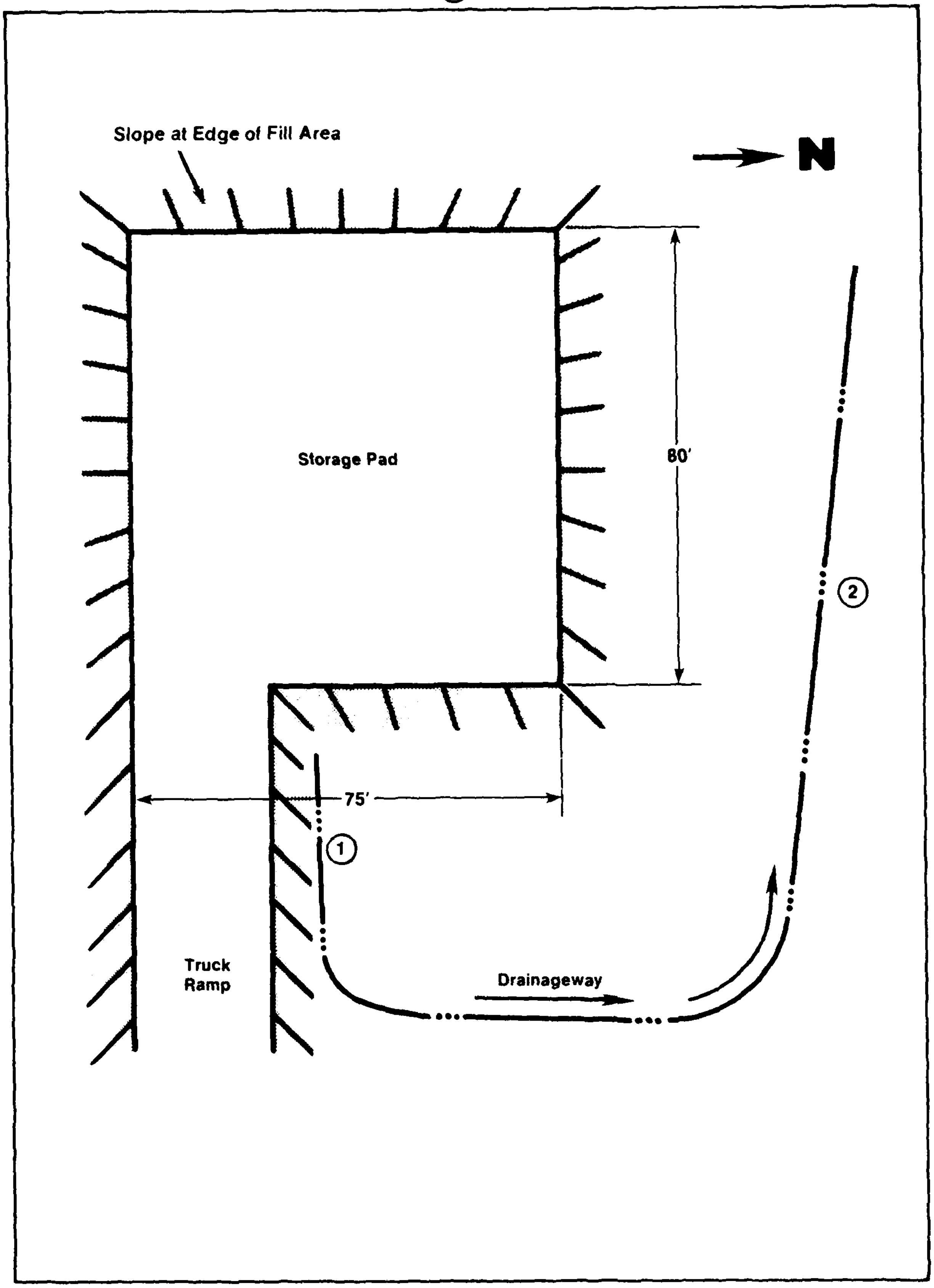

FIGURE 1-5 GENERAL SITE MAP FOR DPDO STORAGE AREA "C"

leaks is visible in the bare stained soil and gravel of the pad surface.

1.3.4 Fuel Storage Area

The Fuel Storage Area is located in the southwest portion of the Base, as shown in Figure 1-6. The site occupies approximately 5 acres of land bordering the east-west runway, and consists of three above-ground storage tanks, fuel loading docks, and associated outbuildings. There are also 2 small buried tanks: one for fuel oil, and one holding tank for waste oil.

The three above-ground storage tanks include two 10,000 barrel tanks for JP-4 and one 5,000 barrel tank for fuel oil number 2. The tanks are enclosed within earth dikes capable of retaining 110 percent of the tank capacities. The dike floors are soil fill and are unlined; the dikes are asphalt-coated for stability.

The tank farm and loading dock area is bounded by both open and covered drainageways which carry surface runoff from the site to a culvert. This culvert runs from the northwest corner of the site, under the runway, and emerges to the north of the runway to discharge into Beaver Creek. Site drainage is discussed in Section 2.3.

Subsurface contamination is evident at the site. In 1980, during excavation for a water line, quantities of Diesel Fuel No. 2 were found in the soil and groundwater approximately 150 feet from tank number 3. As a result of this finding, contaminated soil from the excavation was removed and disposed of off-site. Since a leak from tank number 3 or its feeder lines was suspected, the tank was taken out of service. Oily seepage is also visible in the drainage ditches to the north of the dikes and adjacent to the loading area. A sump pump operating in a valve box near the loading area was observed to discharge oily groundwater seepage.

1.4 CONTAMINATION PROFILE

No large scale industrial operations generating large quantities of hazardous waste have been conducted at DIAP in the past. The generation of waste oils and solvents from clean-

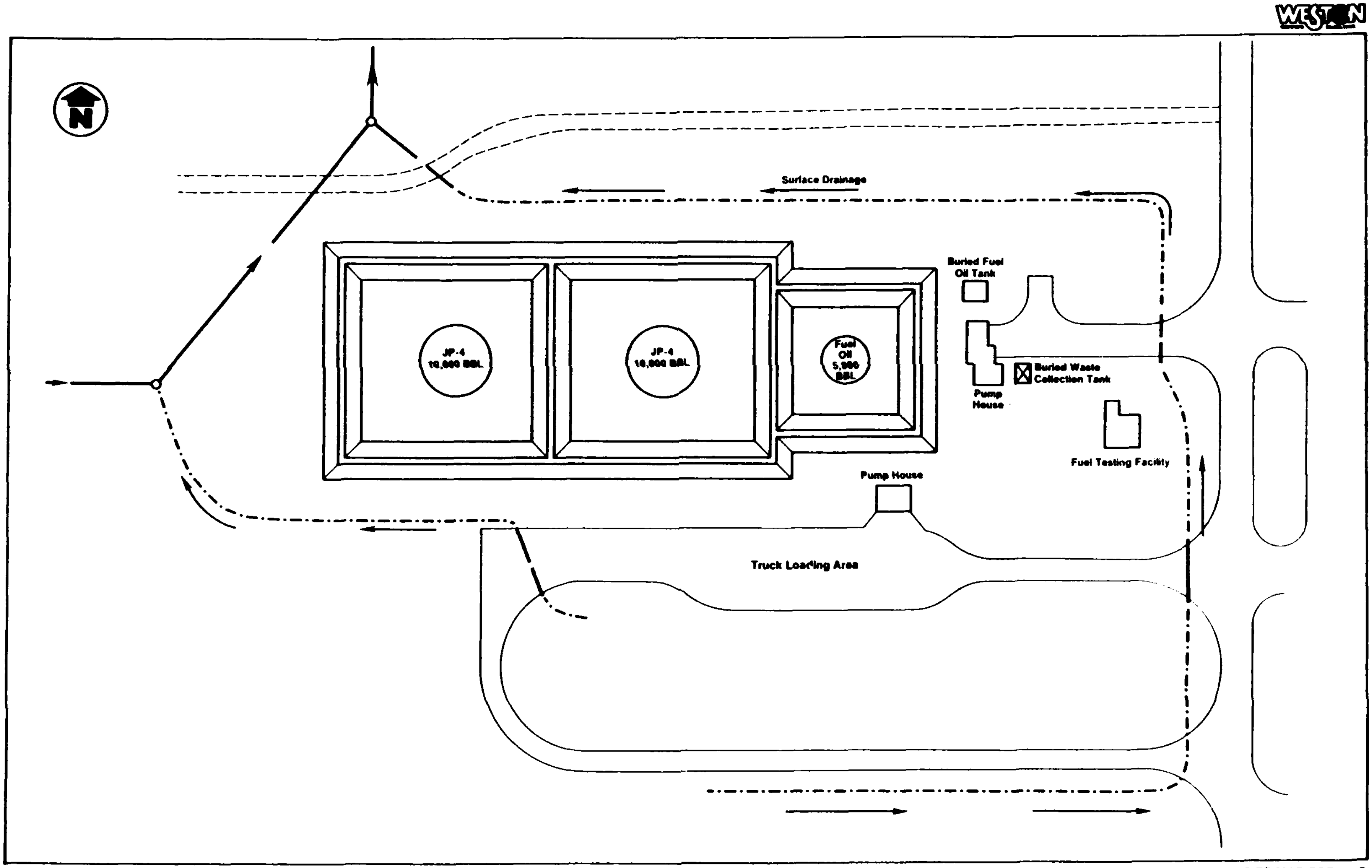

FIGURE 1-6 GENERAL SITE MAP FOR THE FUEL STORAGE AREA

ing and painting operations has been small in comparison to other bases having significant industrial aircraft maintenance or overhaul missions. Much of the combustible wastes have either been burned in fire training exercises or disposed of through DPDO. Approximately 15 empty pesticide containers were found in the area around the Goose Missile site pond during the Phase I survey. Petroleum-based fuel products have leaked from tanks or lines in the fuel storage area.

Based on the Phase I Records Search Report, the key chemical parameters of potential concern at DIAP are oils and greases, pesticides and volatile organics. To develop an initial determination of whether or not past operational and disposal practices have adversely impacted the environment, soils, and ground and surface waters in and around the four sites were sampled and analyzed for the parameters listed in Table 1-2. The details of the field work accomplished are described in Section 3 of this report.

1.5 PROJECT TEAM

The Phase II Confirmation Study at DIAP was conducted by staff personnel of Roy F. Weston, Inc. and was managed through WESTON's home office in West Chester, Pennsylvania. The following personnel served lead functions in this project:

MR. PETER J. MARKS, PROGRAM MANAGER: Corporate Vice President and Manager of Laboratory Services, Master of Science in Environmental Science (M.S.), 18 years of experience in laboratory analysis and applied environmental sciences.

MR. FREDERICK BOPP, III, PH.D., P.G., PROJECT MANAGER: Doctor of Philosophy (Ph.D.) in Geology (Geochemistry), Registered Professional Geologist (P.G.), over 8 years of experience in hydrogeology and applied geological science.

MR. RICHARD C. JOHNSON, PROJECT GEOLOGIST: Master of Arts (M.A.) in Geological Sciences, seven years experience in geotechnical engineering and hydrogeology.

MR. WALTER M. LEIS, P.G., GEOTECHNICAL QUALITY ASSURANCE OFFICER: Corporate Vice President and Manager of the Geosciences Department, M.S. in Geological Sciences, Registered Professional Geologist, over 10 years of experience in hydrogeology and applied geological services.

MR. JAMES S. SMITH, PH.D., LABORATORY QUALITY ASSURANCE OFFICER: Ph.D. in Chemistry, over 16 years of experience in laboratory analysis.

TABLE 1-2

ANALYTICAL PROTOCOL

Site	Potential Contaminants	Media	Analytes
Goose Missile Site Disposal Area	Pesticides	Soils and Surface Water	Aldrin Dieldrin Chlordane DDT isomers Endrin Heptachlor Heptachlorepoxide BHC compounds Methoxychlor
Goose Missile Site Disposal Area	Pesticide	Surface Water	TOC TOX
Fire Training Areas FT-1 and FT-2	Waste Petroleum Products Spent Solvents	Groundwater	Oil and grease TOC Nitrate ion TOX
DPDO Storage Area C	Spent Solvents	Soils	Oil and grease VOA compounds
Fuel Storage Area	Petroleum Products	Groundwater	Oil and grease TOC Lead

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MR. THEODORE F. THEM, PH.D., PROJECT CHEMIST: Ph.D. in Analytical Chemistry, over 10 years of experience in laboratory analysis.

Professional profiles of these key personnel, as well as other project personnel are contained in Appendix C.

1.5.1 Subcontracting

The drilling phase of the Confirmation Study at DIAP was performed by Soil Exploration Company, Inc. of St. Paul, Minnesota under contract to Roy F. Weston, Inc. All soil borings and well installation work was conducted under direct supervision in the field by WESTON geologists.

1.6 FACTORS OF CONCERN

Several factors of concern should be highlighted at the outset of this Confirmation Study Report, which the reader should consider in the review of subsequent sections.

- o DIAP overlies permeable glacial till deposits which are generally saturated with groundwater within only a few inches or feet of ground surface. These till deposits represent the principal potential source of groundwater supplies in the Duluth area. These deposits do not comprise a "Sole Source Aquifer" in the context either of Section 214e of the Safe Drinking Water Act of 1974, as amended, or of generic classification. Groundwaters of the State are classified as to their potential useage: Class 1, domestic consumption; Class 3, industrial consumption; Class 4, agricultural and wildlife; and Class 7, limited resource value. Groundwater in the glacial till deposits is classified as Class 1 for domestic consumption. These deposits are not extensively developed for groundwater supplies in the area because of limited potential.

- o Natural and manmade surface drainageways at DIAP are either immediately adjacent to or proximal to the four sites under investigation here. Much of this surface drainage converges, via the Beaver Creek Drainage Basin, to Wild Rice Lake Reservoir, a surface water body which is used mainly for recreation. The Beaver Creek Drainage Basin and Wild Rice Lake are classified by MPCA as being suitable for all classes of usage except domestic consumption.

- Two of the sites under investigation here are located near the DIAP boundary. These areas are near surface drainageways which are most probably effluent streams due to the shallow water table. Effluent streams receive discharge of water table groundwater, and their annual base flow is sustained by this phenomenon. If contaminated groundwater exists in close proximity to an effluent stream, then a potential exists for contaminant transport to occur off-base with a minimum travel time factor.

SECTION 2

ENVIRONMENTAL SETTING

2.1 REGIONAL GEOLOGY

Duluth, Minnesota, lies on the southern margin of the Superior Province of the Canadian Shield. This is a region of Pre-Cambrian sedimentary and igneous rocks that have subsequently been metamorphosed and deformed. The DIAP area is underlain by bedrock of the Duluth Complex, which consists of several types of intrusive igneous rocks. The base of the complex dips irregularly toward Lake Superior. Structurally, the Duluth Complex is located on the western limb of the Superior Syncline, the axis of which corresponds roughly to the axis of Lake Superior (Sims and Morey, 1972).

The Pre-Cambrian bedrock of the Duluth area, and northern Minnesota in general, have been scoured by glaciers of Pleistocene age which removed any younger rocks overlying this Pre-Cambrian surface. The last glacial period, the Wisconsin, retreated from the Duluth area leaving behind a thin veneer of glacial drift. The glacial drift in the Duluth IAP area consists of a relatively level layer of low to moderately permeable unstratified sands, silts and clays with locally occurring peats. The unconsolidated sediments range in thickness from 10 to 60 feet over the underlying bedrock.

2.2 PHYSIOGRAPHY

The Duluth IAP lies within the north shore highland section of the Superior Upland. The area is a typically glaciated terrain with generally poor, deranged drainage, irregular low relief, and numerous shallow lakes and bogs occupying the low areas. Deranged drainage is typified by short stream segments, swampy lands and numerous ponds. The surface elevation at DIAP ranges from approximately 1,400 to 1,430 feet above mean sea level. To the east of DIAP, the land surface drops abruptly across the City of Duluth to Lake Superior, the surface of which is about 602 feet above mean sea level.

As is typical of airfields, the Duluth IAP has been subject to much earth moving, further affecting topography and drainage. Each of the sites investigated here is located on structural fill or otherwise disturbed ground.

2.3 GROUNDWATER AND SURFACE DRAINAGE

Two hydrogeologic units underlie DIAP: 1) the crystalline bedrock, where groundwater is found in limited quantities in fracture zones; and 2) the overlying glacial drift, where groundwater occurs at water table conditions in the unconsolidated sediments.

Because of its limited capacity to produce water and the availability of abundant surface water, the bedrock has not been developed as an aquifer in the Duluth area. The glacial drift does have a limited capacity as an aquifer and has been developed in the past for farm and domestic use by low production, hand-dug or shallow drilled wells.

The hydraulic head in the bedrock near DIAP is similar to that in the overlying glacial drift, while the bedrock permeability is generally much lower than the overlying sediments. This means that while the two units are hydraulically interconnected, the vertical flow from the sediments to the bedrock is low (Engineering Science, Inc., 1982). The principle flow path of groundwater in the area is thus direct recharge from ground surface to the shallow water table in the glacial drift, then horizontal flow in the water table to discharge in local streams and ponds. Figure 2-1 is a generalized schematic illustrating this flow system. Throughout the DIAP area the shallow groundwater table provides discharge to streams and their tributaries. The water table is also continuous with marsh and bog areas which are essentially areas where the water table is at or above the ground surface.

Surface drainage at DIAP flows to two drainage systems: one flowing north to Wild Rice Lake, and one flowing south via Miller Creek to the St. Louis river. As shown in Figure 2-2 drainage from the eastern and southern part of DIAP flows toward Miller Creek. Drainage from the northern and western areas of the airfield drains to Beaver Creek, which then discharges into Wild Rice Lake. This system includes drainage ditches from the Fuel Storage Area, the DPDO Storage Area "C" and the Fire Training Areas. The area to the north of the airfield, which includes the Goose Missile area, is largely marshy and drains into two unnamed drainage ways which empty directly into Wild Rice Lake.

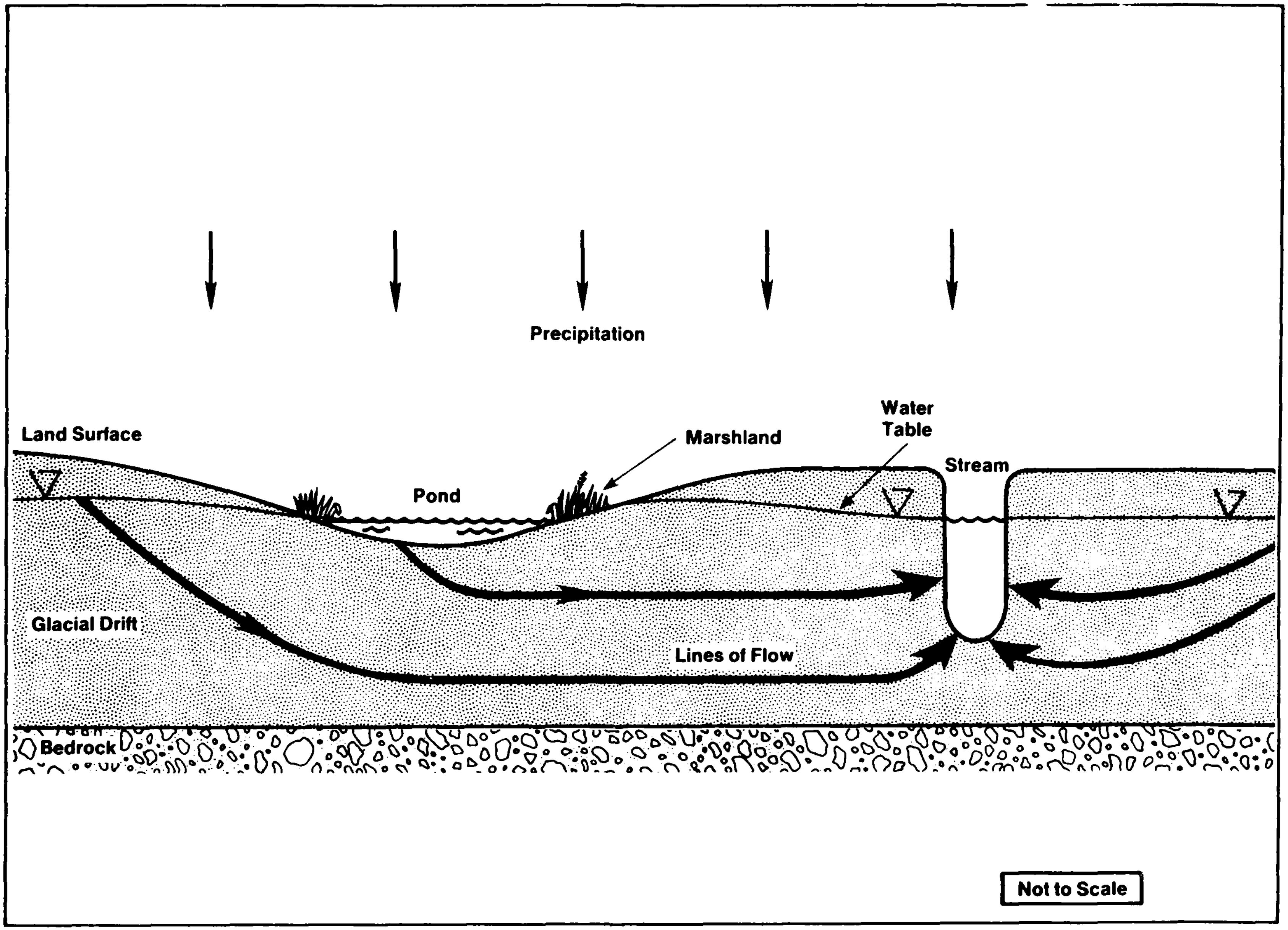

FIGURE 2-1 GENERALIZED CROSS SECTION OF GROUNDWATER FLOW IN GLACIAL DRIFT

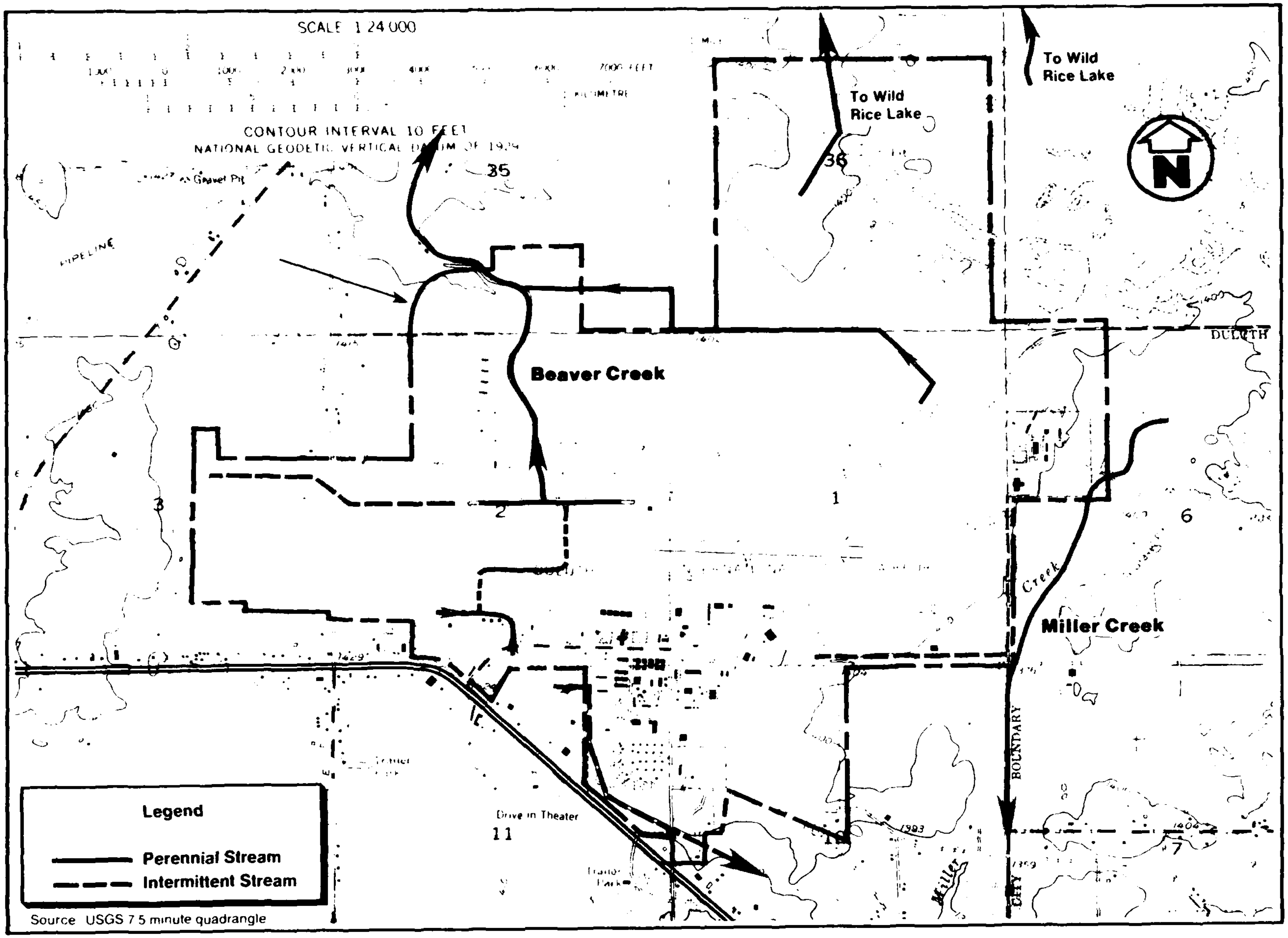

FIGURE 2-2 SURFACE DRAINAGE AT DIAP

SECTION 3

FIELD PROGRAM

3.1 Program Development

Based on the conclusions of the Phase I Records Search and the overall relative Harm Score Ratings, four sites were determined to warrant a confirmatory field investigation. These included: the Goose Missile Site Disposal Area; Fire Training Areas FT-1 and FT-2 (considered as one site); DPDO Storage Area "C"; and the Fuel Storage Area. Locations of these four sites are shown on Figure 3-1.

On 19 October 1982, WESTON conducted a pre-survey site inspection of DIAP and the 11 identified sites listed in the Phase I report. At that time it was decided that WESTON would prepare a work scope which would include an investigation of the five highest priority sites listed in Table 1-1. Following the 19 October 1982 pre-survey inspection, WESTON prepared a Pre-Survey Report, submitted to OEHL in December 1982, addressing the five sites.

Task Order 0025 formalized the proposed work, and is included in this report in Appendix B. This Task Order provided the basis for the implementation of the field program described in the following sections.

3.2 HYDROGEOLOGIC FIELD INVESTIGATION

A field investigation was conducted to define the hydrogeologic and geologic setting at the Base and to assess the possible presence of hazardous environmental contaminants that may have resulted from past waste storage and handling and fuel storage operations at DIAP. Information regarding potential or real impacts of the four sites on area groundwater and surface water was obtained from eleven on-site monitoring wells, 37 exploratory borings, and thirteen on-site surface water and soil sampling locations. The monitoring wells were installed to provide groundwater flow direction and gradient information and also to serve as groundwater sampling locations, to enhance the hydrogeologic investigation and provide surface water ties to the groundwater flow regime. On a site-by-site basis, the field work is summarized in Table 3-1. Stream surface locations were surveyed

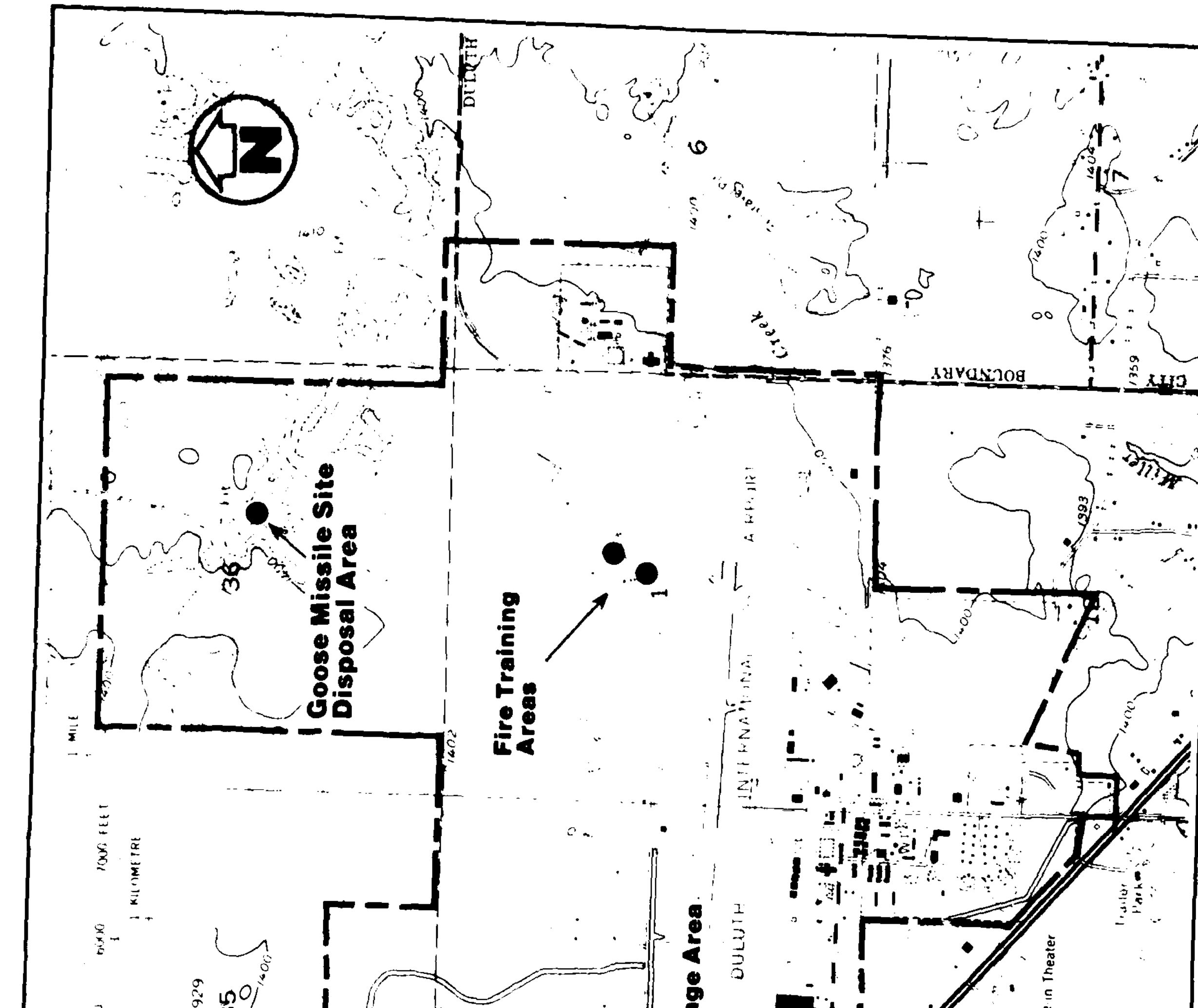

FIGURE 3-1 LOCATIONS OF PHASE II SITES

Table 3-1

SUMMARY OF TECHNICAL WORK SCOPE

Site	Action
Goose Missile Site Disposal Area (Site D-1)	11 sampling locations for sediment and surface water
Fire Training Areas (Sites FT-1 and FT-2)	7 monitoring wells for groundwater sampling and water table elevation survey
DPDO Storage Area "C" (Site S-2)	10 soil borings with continuous sampling to 5 feet 2 drainage ditch sediment samples
Fuel Storage Area (Site SP-1)	20 temporary well points for groundwater elevation survey and location of soil contamination 4 monitoring wells for groundwater sampling 2 test pits Sampling of groundwater from monitor wells and test pits

and surface water samples were obtained.

3.2.1 Schedule of Activity

The field investigation at DIAP was started on October 17, 1983 and completed on January 6, 1984. Table 3-2 is a summary of WESTON's field activities at DIAP.

3.2.2 Drilling Program

The field program at DIAP included 37 soil borings and the construction of 11 permanent groundwater monitoring wells. The work was performed by drilling crews from Soil Exploration Company, Inc., of St. Paul, under the direction of WESTON field geologists. Two drill rigs were on site during the drilling phase. Both were Model CME-55 auger boring rigs, one mounted on a truck bed and the other mounted on a balloon-tired all-terrain vehicle (ATV). The ATV rig was required for Sites FT-1 and FT-2, where the ground was soft and saturated in many places. Locations of the soil borings were selected to define those areas in which soil contamination was most likely to occur. Monitoring well locations were selected to define groundwater flow directions, hydraulic gradients, site geology and to provide discrete upgradient and downgradient sampling points.

3.2.2.1 Exploratory Soil Borings

The soil borings were advanced with 4-inch inside-diameter hollow stemmed augers. Soil samples were taken in advance of the augers using 2-inch outside-diameter split spoon samplers in accordance with Standard Penetration Test Methods (ASTM-D1586). All samples were logged by a WESTON geologist, who recorded information on soil description, penetration resistance to the sampler (sampling blow counts), sample depth, presence of water and other relevant information. The boring logs are presented in Appendix D of this report. Representative soil samples from each sampling interval were preserved in glass jars for later examination. Where soil samples were taken for chemical analyses, specific procedures were followed to ensure sample integrity. These procedures are summarized in Appendix E. At the completion of soil borings where wells were not installed, the bore holes were backfilled with a bentonite-cement grout using tremie methods, and the areas regraded to ensure that the disturbed soils did not become

Table 3-2

FIELD ACTIVITY SCHEDULE

Date	Activity
17 October, 1983	Site visit with drilling contractor to locate well and boring sites, and confirm schedule.
24-29 October 1983	Drilling Rigs on Site. Installed monitor wells at Fuel Storage and Fire Training Areas. Soil sampling at DPDO site. Completion of elevation survey.
14-18 November 1983	Soil and water sampling at Goose Missile Disposal Area. Monitor well sampling. Installation of test pits at Fuel Storage Area. First round of groundwater level measurements.
5-6 January 1984	Second round of groundwater level measurements. Samples of MW-1 through MW-7 for oil and grease analysis.

avenues for surface contamination migrating to the groundwater.

3.2.2.2 Monitor Well Construction

The 11 groundwater monitoring wells were installed in selected borings in the following manner. The auger was advanced to the required depth below the water table. Where refusal in rock was encountered at a higher elevation than the anticipated well completion depth, the rock was cored for a distance of 5 feet to confirm the bedrock or to pass through a boulder. Then appropriate lengths of 2-inch diameter, flush-threaded PVC screen and riser pipe were inserted through the auger. The augers were then withdrawn to several feet above the screen and a gravel pack was poured into the annular space around the well screen to the base of the auger. Next, bentonite pellets were placed on top of the sandpack to seal the screened interval from vertical infiltration through the annular space. The seal was completed by pouring a bentonite-cement grout through the augers into the annular space as the augers were withdrawn. Care was taken to prevent collapse of the annular space and to produce a continuous grout seal above the sandpack. Each well was completed with installation of a 4-inch diameter steel protective casing that was cemented in place over the top of the well head. A typical well construction diagram is presented in Figure 3-2. Well completion summaries for all monitor wells are presented in Appendix D. Each well was developed by bailing a minimum of 5 times the volume of standing water in the well casings. No foreign water was introduced into any well during auger drilling or development, and no solvents or glues were used at the casing joints.

3.2.2.3 Fire Training Areas (Sites FT-1 and FT-2)

A total of 7 groundwater monitoring wells were installed at Fire Training Areas FT-1 and FT-2. The wells, numbered MW-1 through MW-7, were located around the perimeters of the two areas with Well MW-4 located between the areas, as shown on Figure 3-3. Wells MW-1 through MW-3 were located along the known northerly perimeter of Fire Training Area FT-2, approximately 75 feet from the fire pit at the center of the site, Wells MW-5 through MW-7 were located along the estimated southerly border of Fire Training Area FT-1, based on its estimated size and location. Because of site regrading, there were no indications in the field of the boundaries of FT-1 or the exact location of the fire pit. Monitoring wells ranged in depth from 15 to 25 feet below land surface, and groundwater was encountered between 1 and

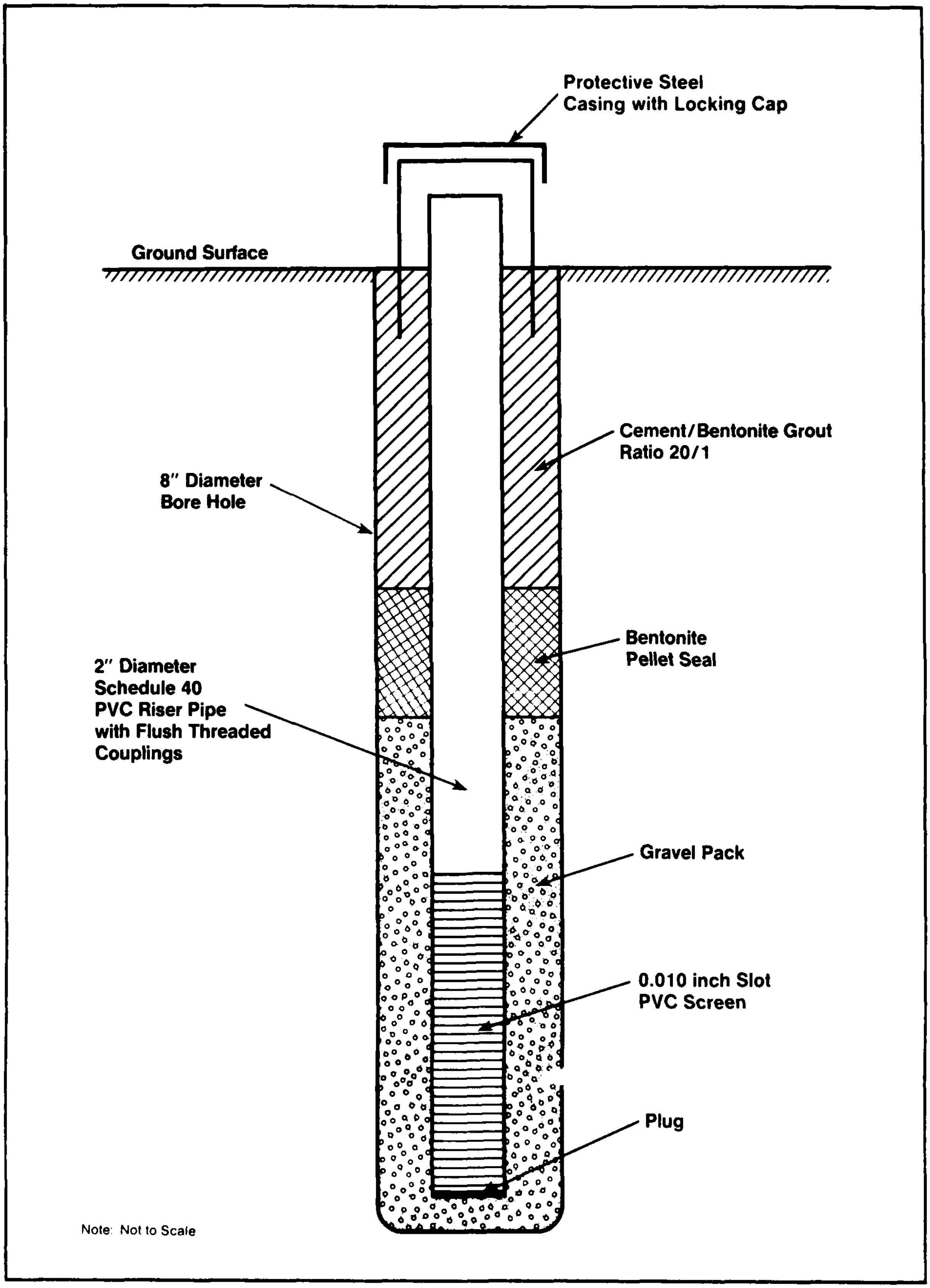

FIGURE 3-2 SCHEMATIC OF TYPICAL MONITOR WELL CONFIGURATION

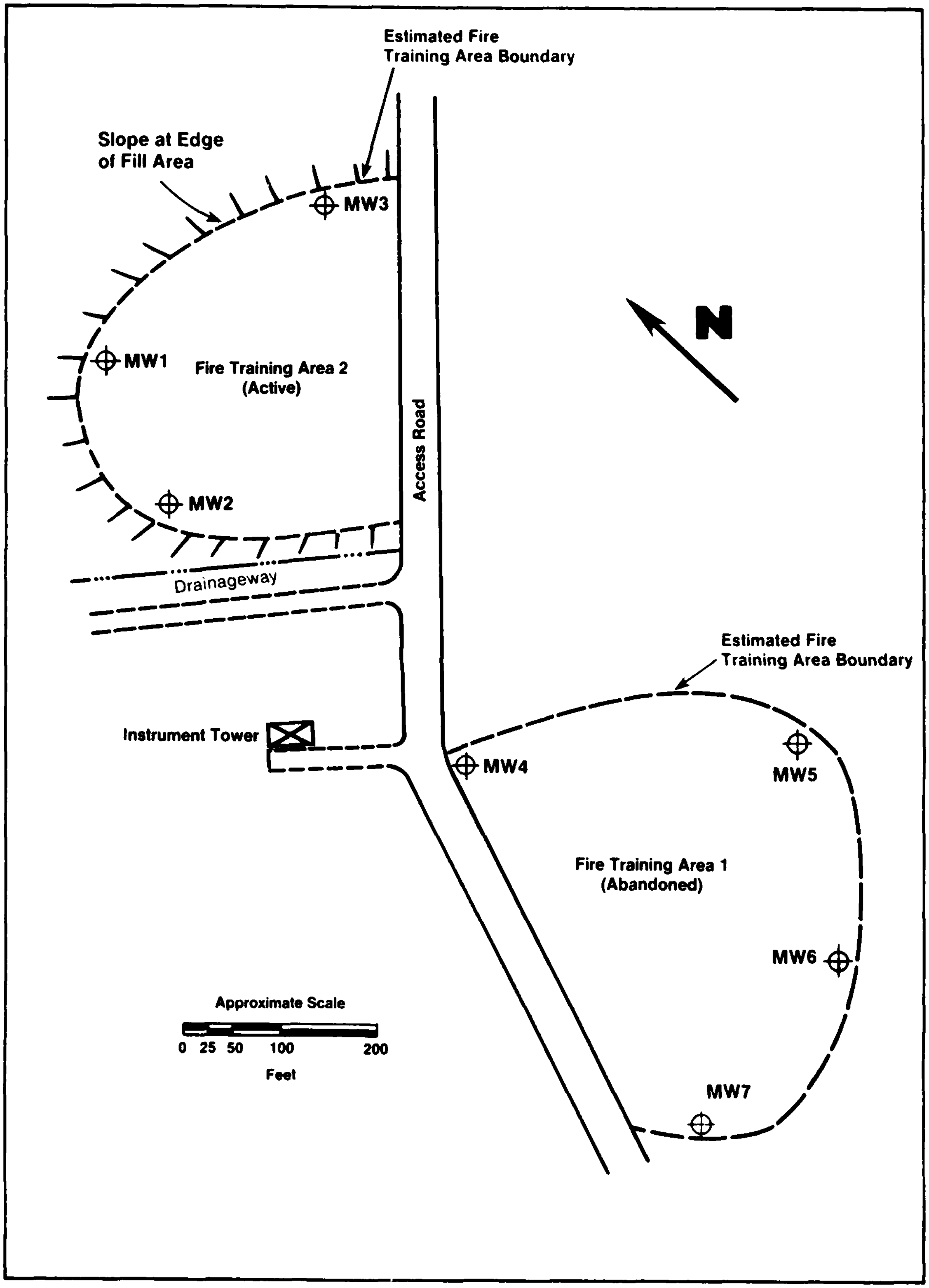

FIGURE 3-3 LOCATIONS OF MONITOR WELLS, FIRE TRAINING AREAS FT-1 AND FT-2

12 feet below land surface. Well screens were installed at a period of relatively high groundwater in this area. The tops of screens were placed below the existing water table in anticipation of later groundwater fluctuations.

All the borings encountered fill soils overlying glacial drift. None of the borings penetrated bedrock. A 1.5 foot diameter boulder was cored at MW-5. A complete discussion of subsurface conditions at the fire training sites is presented in Section 4.1. Table 3-3 summarizes the well construction details and Figure 3-4 graphically presents the well logs.

Periodic air quality monitoring was conducted at the boreholes during and after drilling using an explosimeter and organic vapor detector. The results are presented on the boring logs in Appendix D. There were responses to the explosimeter in borings for MW-2 and MW-3, although there was no response by the organic vapor detector at any of the wells.

3.2.2.4 DPDO Storage Area "C" (Site S-2)

On 26 October 1983, WESTON geologists obtained a series of continuous soil samples collected from ten five-foot deep soil borings installed in DPDO Storage Area "C". A site plan showing the locations of the soil borings is shown in Figure 3-5. WESTON personnel established the locations of the ten boreholes following a preliminary inspection of the area. Specific borehole locations were chosen to provide the most effective sampling coverage of the site. The distribution of sampling locations shows a bias in favor of the northern part of the site where the greatest ground staining was observed. It is also the area farthest from the entry ramp, and so was most likely to have containers on it at any given time. In addition to samples from the storage pad itself, single soil samples were taken at two locations along the drainage ditch associated with the site. These locations are also shown on Figure 3-5.

Five samples were taken at one-foot intervals from each borehole for chemical analysis of volatile organic compounds, and oils and greases. Soil samples were recovered to a depth of 5 feet at the DPDO Storage Area "C" with the object of determining the extent of penetration in the soil of spillage on the pad. A split spoon sampler was used to recover the samples from 1 to 5 feet, with the upper foot of soil being sampled by hand. The split spoons were driven ahead of the advancing auger into undisturbed soil. A single split spoon sample penetrated 2 feet of soil. The resulting sample core recoveries were always somewhat less

TABLE 3-3

SUMMARY OF WELL CONSTRUCTION DETAILS

Monitor Well Number	Approx. Land Surface Elevation In Feet	Top of PVC Casing Elevation in Feet	Screen Interval Depth in Feet	Sandpack Depth Interval in Feet	Geology of Screened Zone
FIRE TRAINING AREA [1]					
MW-1	1433.2	1435.20	15-25	10-25	Dense f-c SAND, some clay
MW-2	1434.1	1436.33	15-25	10-25	CLAY and SAND, some silt & gravel
MW-3	1433.3	1433.43	9-14	8-14	m-cSAND, some clay, a little gravel
MW-4	1436.7	1439.30	10-20	8-20	Dense m-cSAND, a little clay
MW-5	1436.0	1438.47	10-20	6-20	f-cSAND, some clay and silt, a little gravel
MW-6	1434.9	1437.28	7-17	3-17	fine SAND and SILT, a little gravel
MW-7	1437.5	1440.00	10-20	5-20	Dense f-mSAND, a little gravel and silt
FUEL STORAGE AREA [2]					
MW-8	1407.6	1410.67	3-13	2.5-13	Fill: loose SAND, a little clay and gravel
MW-9	1408.4	1410.29	5-15	4-15	CLAY, some Sand and little gravel
MW-10	1405.1	1407.09	3-13	2.5-13	m.SAND, Some silt and gravel
MW-11	1408.2	1410.15	3-13	2.5-13	Firm SILT and CLAY, a little gravel

1 - Fire Training area elevations referenced to base of instrument tower. Approximate elevation 1440 feet (MSL).

2 - Fuel Storage area elevations referenced to drain pit. Approximate elevation 1406 feet (MSL).

EXPLANATION

f = fine
m = medium
c = coarse

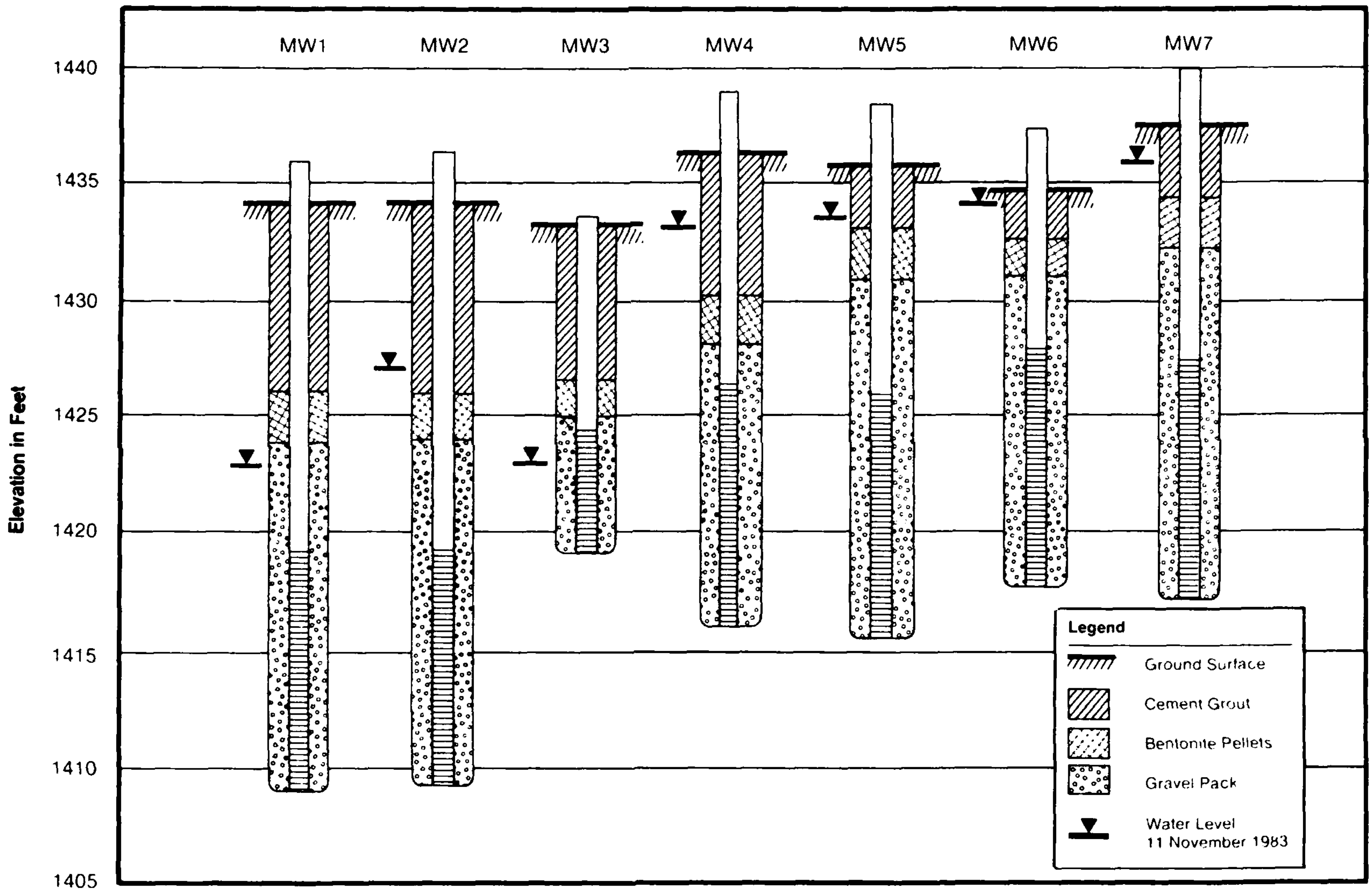

FIGURE 3-4 SUMMARY OF MONITOR WELL CONSTRUCTION, FIRE TRAINING AREAS FT-1 AND FT-2

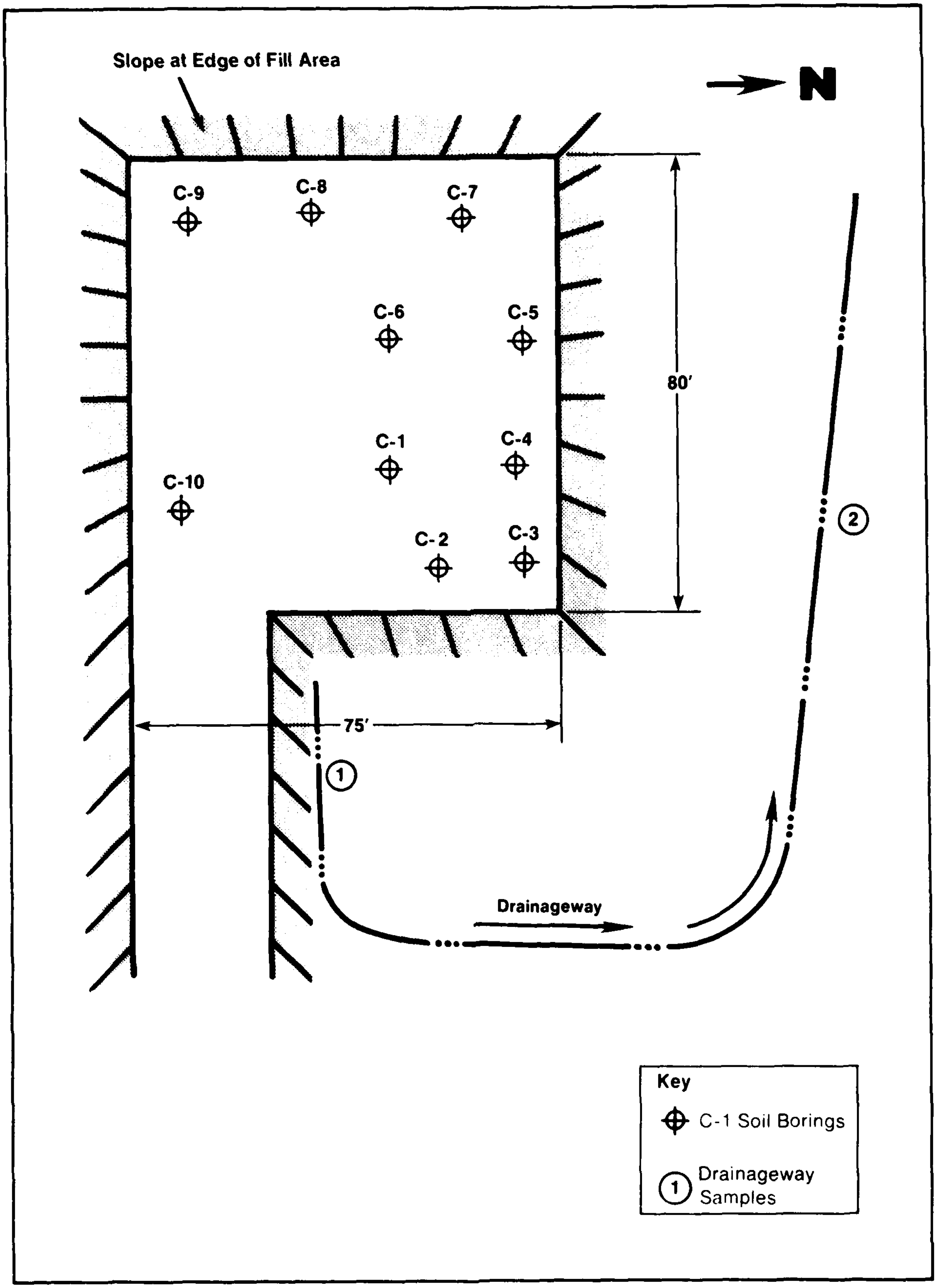

FIGURE 3-5 LOCATIONS OF SOIL BORINGS AND SURFACE SEDIMENT SAMPLES, DPDO STORAGE AREA "C"

than 2 feet; only highly cohesive soils yield full core recovery. The recovered soil cores were divided into 2 one-foot increment sections, placed in appropriate sample bottles and labeled. Although the precise assignment of a depth interval of partially recovered samples is somewhat qualitative, the relative position of each soil sample in the soil column is accurate. Between samples, the split spoon was washed thoroughly with water and detergent, then rinsed with deionized water. Between borings the augers were washed clear of soil particles. All sample handling equipment was also washed and rinsed between samples.

The sample bottles were packed in 1 gallon cans, filled with vermiculite. The cans were placed in tri-wall shipping cartons and shipped air express to WESTON's laboratory.

The drainageway samples at the DPDO storage area were taken at a later date and packaged and shipped with the Goose Missile site samples as described below. Since the bottom sediments in the drainageway were deeply matted with vegetation, a hand corer could not be used and only surface grab samples were taken.

During the soil boring activity the boreholes were monitored with an HNu[1] organic vapor detector. The results of the monitoring are presented in the boring logs (Appendix D). All of the boreholes showed relatively low organic vapor detector readings of from 1 to 62 ppm above pre-determined background levels. These readings indicate that organic vapors were collecting in the open boreholes. The source of these vapors is assumed to be volatile compounds in soil. A possible interference with these readings could be as trivial as vehicle exhaust gasses that have not dissipated. However, all truck exhausts were directed away from the borehole and background readings were taken regularly above the borehole as a reference reading.

3.2.2.5 Fuel Storage Area (Site SP-1)

At the beginning of the investigation, twenty soil borings ranging in depth from 6 to 16 feet were made into the water table. The locations of these borings are shown on Figure 3-6. The borings were located so that the groundwater surface in the broad area around the tank farm could be identified, with a concentration of borings near the tanks where contamination was suspected. Limited access prevented the location of borings immediately adjacent to the north and west berms.

All borings were advanced by hollow stemmed auger; continuous split spoon samples were recovered and soil samples were

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[1] An HNu is a photoionization detector which measures non-specific organic and several inorganic vapors and gases. It does not respond to methane, H_2S and HCN.

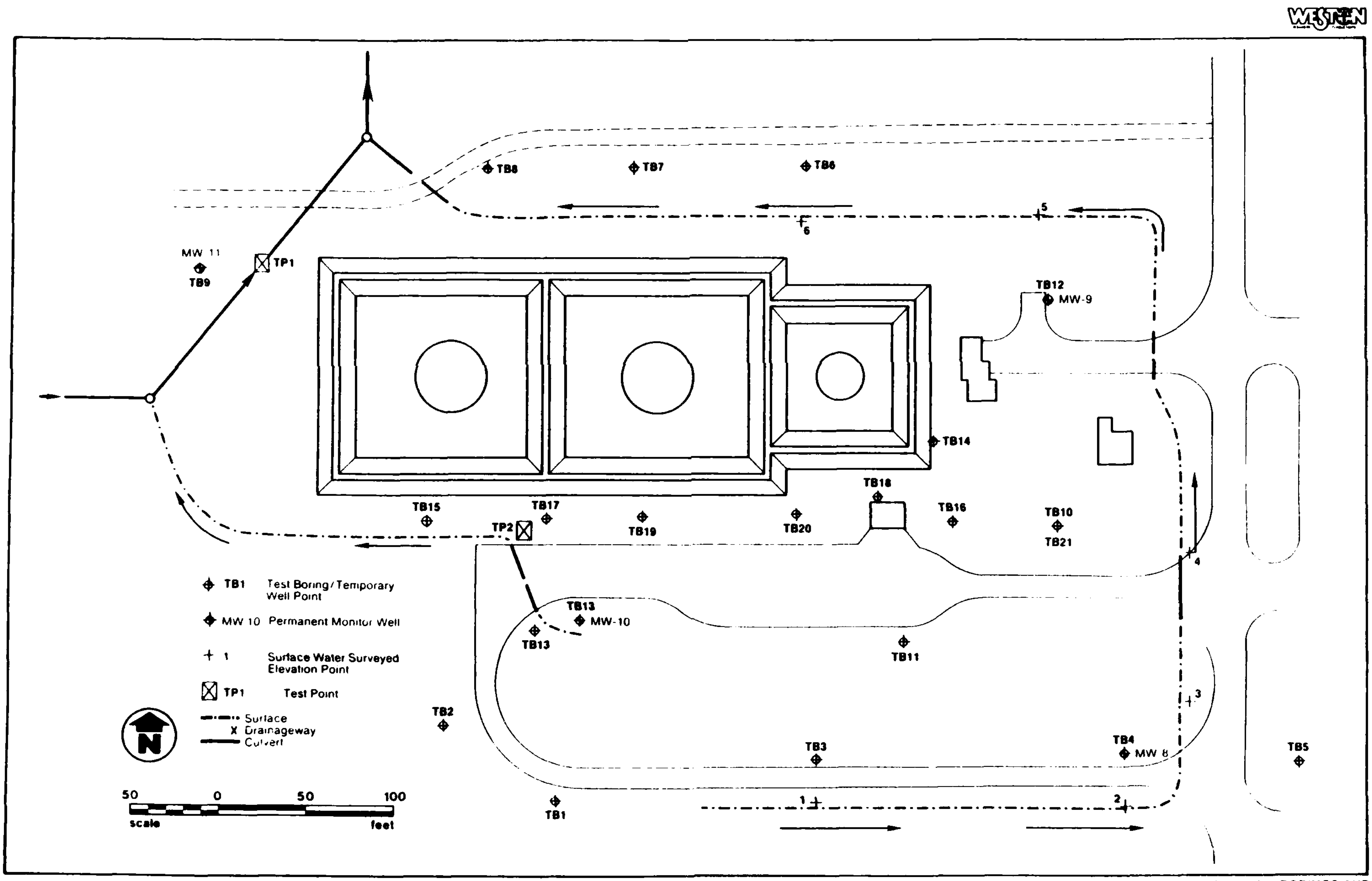

FIGURE 3-6 LOCATIONS OF SOIL BORINGS AND TEST PITS, FUEL STORAGE AREA

logged by WESTON's geologist. Boring logs are presented in Appendix D of this report. At the completion of each boring, a temporary PVC well point was installed in each hole. These points were simply two-inch diameter pipe with the ends wrapped in geofabric to prevent clogging. The points were placed one to five feet below the groundwater surface. Because of their construction and the short time in the ground (24-48 hours) the points were not used for measuring fuel product thickness. Some emulsified fuel and skims were observed on the water surface, but they were not representative of fuel thickness on the groundwater surface.

As the borings logs (Appendix D) indicate, the soils encountered beneath the site were mostly fill consisting of locally derived sands, silts and clays with some peat layers. The backfill does not differ greatly in composition from the undisturbed subsoil, and may be more extensive than the logs indicate.

During the drilling, fuel product odors were obvious in many of the soil samples, particularly in borings adjacent to the tank berms. Fuel product skims were also observed on the water surface in the well points. The presence of fuel odors in soil samples is noted in the drilling logs (Appendix D). Table 3-4 indicates where fuel product was observed in the well points.

Oily seepage was also observed in soils along the banks of the drainageway north of the tanks and along the ditch located south of the tanks adjacent the loading area. A sump in the loading area also periodically pumps oily water that has seeped into a valve box set below grade. Both drainageways enter a buried culvert which carries the drainage northwest away from the site.

At the completion of the temporary well point installation, the top of each well point was surveyed for relative elevation. These points were used as references to determine the relative elevation of the groundwater surface that was subsequently measured at each well point. The elevations of the water surface in the drainageways around the site were also surveyed at regular intervals since the surface water is continuous with the water table in the tank farm area. The locations of these points are also shown on Figure 3-6.

Groundwater stabilized in all the well points at approximately 1 to 8 feet below the ground surface. After the well

WESTON

TABLE 3-4

GROUND WATER AND STREAM ELEVATIONS
FUEL STORAGE AREA (26 October 1983)

Well Point	Ground Surface Elevation (ft.)[1]	Top of Casing Elevation (ft.)[1]	Depth to Water (ft.)	Groundwater Elevation (ft.)[1]
1	99.62	102.52	5.35	97.17
2	99.60	101.80	4.74	97.06
3	99.88	104.78	7.67	97.09
4	100.89	104.56	7.35	97.21
5	101.60	101.65	1.79	99.86
6	101.50	100.75	7.74	92.97
7	101.20	106.25	9.61	96.65
8	98.42	98.43	4.01	94.42
9	101.00	101.15	5.93	95.22
10	99.70	98.58	2.44	97.35
11	99.85	104.88	7.50	97.38
12	100.44	100.44	6.37	94.07
13	99.66	99.66	2.38+	97.28
14	100.04	102.34	5.26+	99.06
15	98.89	103.96	7.44+	96.52
16	99.32	101.32	3.19+	98.23
17	98.97	101.11	3.78+	97.13
18	99.69	101.51	3.34+	98.23
19	99.12	99.37	1.87+	97.50
20	99.19	101.75	2.25+	99.50

Stream Elevation Locations	Stream Elevation (ft.)
1	96.98
2	96.37
3	95.90
4	94.70
5	92.20
6	91.40
7	

1 - Elevations are reference to temporary arbitrary datum on site

+ - Fuel oil observed in boring.

points had been allowed to stabilize overnight, a round of water level measurements was taken. This data was referenced to the surveyed top of well point elevation to determine the groundwater gradient and direction of flow across the site. These measured elevations are presented in Table 3-4, and were field-contoured to produce the preliminary water table map shown in Figure 3-7. The results indicate the general groundwater flow direction to be to the northwest, although around the tank farm the direction of flow at any point is largely influenced by the surface drainage system. These observations were the basis for locating the four permanent monitoring wells.

After the groundwater flow directions were determined by the temporary well point survey, permanent monitoring wells (MW-8 through MW-11) were installed in test borings TB-4, TB-12, TB-13 and TB-9, respectively, as shown in Figure 3-6. The locations were selected for the following reasons: MW-8 is hydrologically upgradient of the site; MW-9 and MW-10 are located between the tank farm and nearby drainageways and are within the local flow paths of the potential contamination source. MW-11 is located in a position downgradient of the loading area and south edge of the tank farm where contamination was observed. The north edge of the tank farm discharges to the drainageway which forms a hydraulic barrier along the northern border of the site.

Each well was constructed as described in Section 3.2.2.2. The screens were 10 feet long with .010-inch factory slots. The bottoms of the well screens were placed from depths of 13 to 15 feet with the top of each screen protruding above the water table where practical in order to intercept any fuel products floating on the water table surface. Well construction details for the fuel storage area are presented in Table 3-3 and Figure 3-8. Boring logs and well construction details for each well are presented in Appendix D.

Two test pits were also dug with a backhoe at the tank farm in areas that were suspected to be discrete avenues of contaminant migration. The locations of Test Pits 1 and 2 are shown on Figure 3-6. Test Pit 1 was located adjacent to a buried culvert on the northwest site of the tank farm. The backfill around the pipe may serve to intercept and divert fuel contaminants moving in the groundwater from the tank farm. This migration would not be detected by monitoring well MW-11. Test Pit 2 was located near the tank berms adjacent to a drainage ditch that runs around the western half of the site and contains evidence of fuel oil contamination.

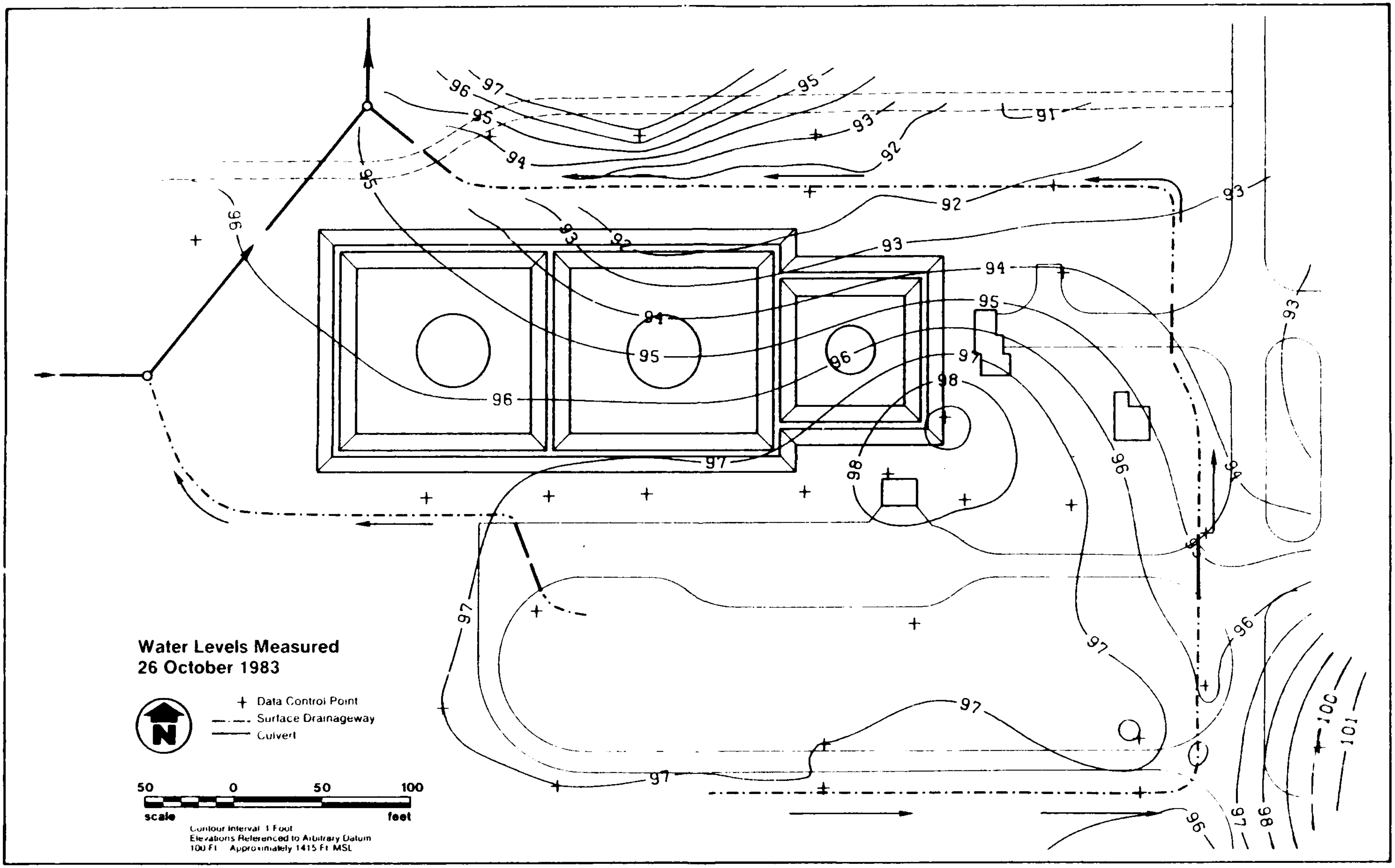

FIGURE 3-7 WATER TABLE MAP FOR FUEL STORAGE AREA BASED ON TEMPORARY WELL POINT SYSTEM

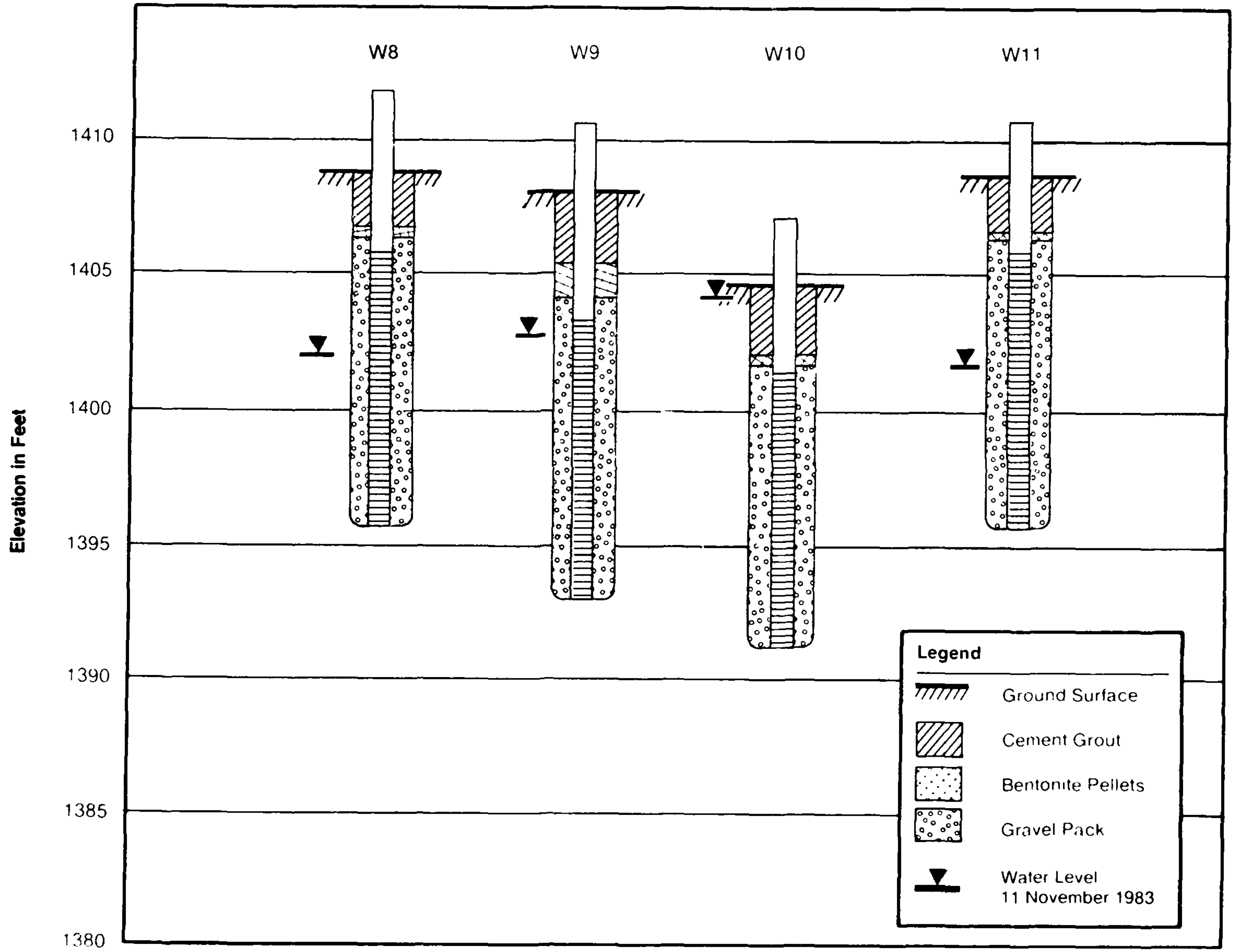

FIGURE 3-8 SUMMARY OF MONITOR WELL CONSTRUCTION, FUEL STORAGE AREA

Test Pit 1 was 10 feet deep and encountered a 30 inch concrete drain pipe at 6 feet. The soil was silty sand with a layer of peat from 5 to 6 feet. From 6 to 10 feet the soil was moist with a strong fuel odor. Very little water was present although the bottom of the pit was below the elevation of the water table.

Test Pit 2 encountered clayey sand fill to a depth of 4 feet, and grey-green sandy clay from 4 to 5 feet. There was rapid seepage of oily water from the sides of the pit during excavation.

HNu readings taken at the top of the test holes and next to the excavated soils were not above background levels. Explosimeter readings were also taken above the test holes mainly for safety reasons, since the odor of fuel was obvious. Explosimeter measurements at TP-1 and TP-2 were respectively less than 10 percent and 20 percent of the lower explosive limit.

At the completion of each pit a 10-foot PVC well screen was placed in the pit before backfilling. These monitoring points were installed for short term monitoring of water levels and do not meet permenant monitoring well specifications or have protective steel caps.

3.2.3 Surface Water and Bottom Sediment Program

3.2.3.1 Goose Missile Site Disposal Area (Site D-1)

At the time of the sampling (November 16, 1983) the Goose Missile Site (GMS) disposal area pond was frozen and all inlets and outlets were dry. Eight sampling locations were located in the pond area itself with 3 of those locations adjacent to the 2 inlets and 1 outlet. One sampling location was established 50 feet from the pond in the larger inlet; 2 sampling locations were established at intervals along the outlet drainageway. All sample locations are shown on Figure 3-9.

Since the pond was frozen, samples were taken at chosen locations by breaking through the ice. Pond water grab samples were taken first before any disturbance of bottom sediments occurred. Water depths at the eight sampling location varied from 0.7 to 2.5 feet.

The bottom sediments at the Goose Missile Site pond were taken with a hand held sediment corer consisting of an 18-inch PVC sampling tube attached to a driving weight. The apparatus dropped on a line into the water with the weight driving the tube into the sediments. Once the sampler had penetrated the sediments, a weighted "messenger" was sent down the line to close the top of the sampling tube. This produced a

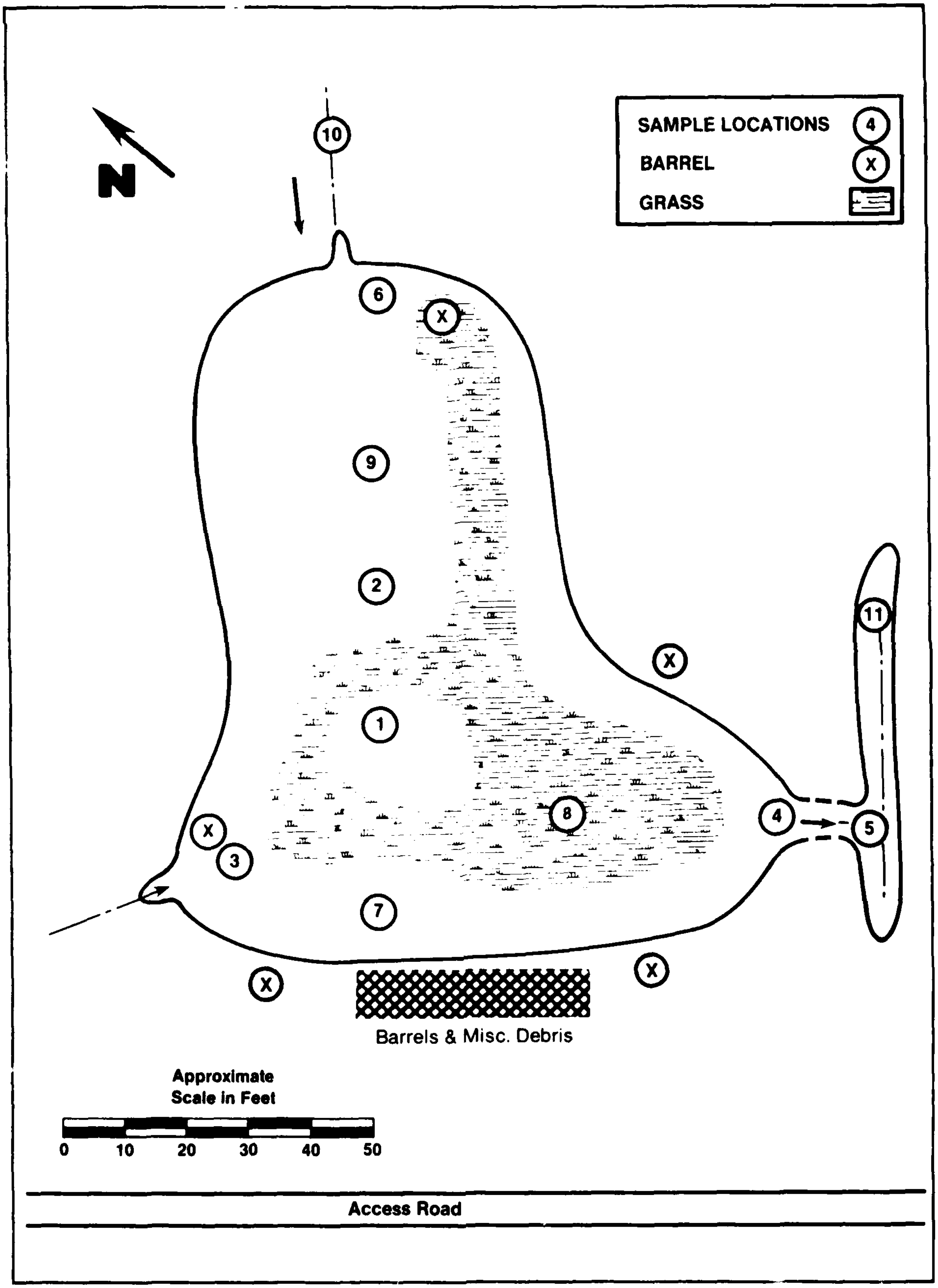

FIGURE 3-9 LOCATIONS OF BOTTOM SEDIMENT AND SURFACE WATER SAMPLING LOCATIONS, GOOSE MISSILE SITE DISPOSAL AREA

suction which held the soil in the tube during recovery. Sample recoveries from the loose, mucky soil ranged from 4 to 6 inches. All soil was removed and the sampler rinsed with deionized water after each sample was recovered. The soil samples were placed in appropriate containers and labelled as to location.

3.2.4 Field Testing

In order to maximize the data collected from each of the installed monitoring wells, various field tests and testing techniques were used. Field testing involved: surveying of top-of-casing and nearby surface water elevations to provide water level elevation control; water level measurements to provide hydrogeologic and hydraulic gradient data; and field water quality testing to provide pH, temperature and specific conductance data. Each of these field tests is described in the following paragraphs.

3.2.4.1 Surveying

All temporary well points stream surface points and permanent groundwater monitoring wells were surveyed for elevation using a standard tripod mounted optical leveling device. The purpose of the survey was to determine the relative elevations of water in the wells which would enable the gradient and direction of groundwater flow to be determined. Elevations were determined to the nearest .01 foot. The temporary well points were referenced to an arbitrary datum at the Fuel Storage Area. The four monitoring wells at the Fuel Storage Area were referenced to a concrete drain pit in the truck loading area. The wells in the fire training areas were referenced to the base pad of the instrument tower adjacent to the site. These approximate elevations were obtained from plant drawings. Survey data is summarized in Table 3-5.

3.2.4.2 Water Level Measurements

A complete round of water level measurements was made simultaneously with the water sampling program conducted on 14 through 18 November. A battery operated Soil Test Model DR-760A Water Level Probe was used. All readings were obtained with respect to the top of the PVC casing. Table 3-5 contains a listing of all readings and calculated water level elevations.

3.2.4.3 Field Water Quality Testing

Field water quality testing was conducted on each well. Specific conductance and temperature were measured in the

TABLE 3-5

SUMMARY OF MONITOR WELL CONSTRUCTION AND GROUND WATER ELEVATION. DIAP

Monitoring Well Number	Approximate Land Surface - Elevation in Feet	Top of PVC Casing Elevation in Feet	Screen Interval Depth in Feet	Groundwater Elevation in Feet (11/11/83)
Fire Training Area (1)				
MW-1	1433.2	1435.20	15-25	1422.4
MW-2	1434.1	1436.33	15-25	1426.7
MW-3	1433.3	1433.43	9-14	1422.9
MW-4	1436.7	1439.30	10-20	1433.4
MW-5	1436.0	1438.47	10-20	1433.7
MW-6	1434.9	1437.28	7-17	1434.6
Fuel Storage Area (2)				
MW-8	1407.6	1410.67	3-13	1403.8
MW-9	1408.4	1410.29	5-15	1403.2
MW-10	1405.1	1407.09	3-13	1404.4
MW-11	1408.2	1410.15	3-13	1401.8

(1) Fire Training Area elevations referenced to base of instrument tower and for approximate elevation 1440 feet (MSL).

(2) Fuel Storage Area elevations referenced to drain pit. Approximate elevation 1406 feet (MSL).

field using a Yellow Springs Instrument Company Model 33 Meter. The pH was measured in the field using an Analytical Measurements Model 107 pH Meter. Field water quality testing was conducted concurrently with water quality sampling during the week of November 14, during which time all monitoring wells and surface water sampling points were tested for field water quality parameters.

3.2.5 Water Quality Sampling

The purpose of the water quality sampling program was to identify, insofar as possible at the level of a Stage 1 survey, the location, concentration and areal extent of any contamination present in the hydrogeologic environment. From this information it would be possible to deduce the general direction in which these contaminants are migrating and their probable origin. To achieve these goals efficiently, specific field procedures were developed for purging the wells, collecting the samples, and ensuring field quality control. These procedures have been used to obtain a single complete set of representative samples for chemical analysis from the monitoring wells and surface water. The sampling and quality assurance plans used to accomplish these goals are contained in Appendix E. Sample chain-of-custody documentation is contained in Appendix F. Standard laboratory analysis protocols used in the analysis of these samples are listed in Appendix G.

The laboratory analytical protocols were standard methods as listed below:

- o Oil and Grease Total Recoverable - EPA Method 413.2 (Spectrophotometric infrared)
- o Lead - EPA Method 239.2 (Atomic Absorption, furnace techniques)
- o Volatile Organics in Soil - Headspace Method 5026, EPA SW846, Quantification of GC-MS, EPA Methods 601 and 602.
- o Total Organic Halides (TOX) - EPA Method 450.1
- o Total Organic Carbon (TOC) - EPA Method 415.1
- o Pesticides - EPA Method 608, Organochlorine, Pesticides and PCB's

A special protocol for oil and grease in soils was developed by WESTON and is included in Appendix G.

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SECTION 4

RESULTS

4.1 SITE INTERPRETIVE GEOLOGY

A detailed review of available geologic data obtained during the Records Search and subsequent on-site data generated during the Phase II investigation revealed that DIAP is underlain by a thin sequence of non-stratified glacial till deposits that unconformably overly Pre-Cambrian Age igneous and metamorphic units. DIAP is immediately underlain by low to moderately permeable sands, silts and clays of glacial origin. The Confirmation Stage program focused on geologic exploration and monitoring well construction in the unconsolidated till deposits. Drilling at Fire Training Areas FT-1 and FT-2 encountered fill material to depths of between 5 feet at Site FT-1 and 10 feet at Site FT-2. This fill material appears to have been borrowed locally, and may have been derived from levelling operations during construction of the runways and main base areas. Beneath the fill material glacial till was encountered. This till is a laterally continuous but heterogeneous deposit of interbedded sands, silts and clays, with frequent gravel lenses and larger cobbles and boulders. A large boulder was cored during drilling of monitor Well MW-5, and a probable boulder was encountered at the bottom of the boring for monitor Well MW-3. Bedrock was not encountered during drilling, so based on the depth of borings, the base of the till is at least 14 to 25 feet below the surface.

Drilling at DPDO Storage Area "C" encountered only fill materials in all 10 of the soil borings. At the Fuel Storage Area similar conditions were encountered to those of the Fire Training Area. Fill material was encountered to depths of from 3 to 6 feet. An organic clay and peat layer was encountered from 3 to 5 feet deep in several borings, which was interpreted as an original, marshy land surface. The till, encountered at depths of 6 to 8 feet, was more clay-rich at this site than at the Fire Training Areas, and it extended continuously to below the water table. No bedrock or boulders were encountered.

As indicated by the split spoon blow counts shown on the boring logs in Appendix D, the density of both the fill and till materials increases rapidly with depth. Since increasing density of a given soil type indicates greater compaction and its resulting reduction in pore spaces (porosity) it is probable that permeability of the till decreases with depth. This would indicate that groundwater flow rates, and, therefore, the potential for transmitting entrained contaminants, would also decrease with depth. Recharge to the groundwater table would tend to move laterally in the groundwater table toward surface discharge points. A lesser portion of the groundwater flow would migrate vertically to the underlying bedrock.

4.2 SITE GROUNDWATER CONDITIONS

The results of water level readings from the newly installed wells at the Fire Training Areas and the Fuel Storage Area demonstrate that groundwater occurs under shallow, water table conditions within the fill and till deposits underlying DIAP. Groundwater elevations are less than 13 feet below land surface at all wells (Tables 3-4 and 3-5). Since water level readings were taken in November 1983, the results probably represent seasonally low conditions.

During seasonally high levels, such as after the spring thaw, recharge to the water table increases. This would produce increased flow gradient in the groundwater. At the same time the increased percolation would tend to drive more contaminants, if present, from the subsoil to the groundwater table. These seasonal fluctuations in water elevations, change in gradients, and contaminant distribution can be determined by periodic (such as quarterly) monitoring of groundwater levels and water quality. Recommendations for implementing a quarterly monitoring program are included in Section 6.

4.2.1 Fire Training Areas (Sites FT-1 and FT-2)

4.2.1.1 Groundwater Flow

Figure 4-1 presents a contour map of the water table elevations contained in Table 3-5 for the monitor wells in the Fire Training Areas. Groundwater flow is generally perpendicular to the contours in the direction of lowering head. The gradient of flow is equal to the drop in head along any given flow line divided by the length of the flow line, expressed mathematically as:

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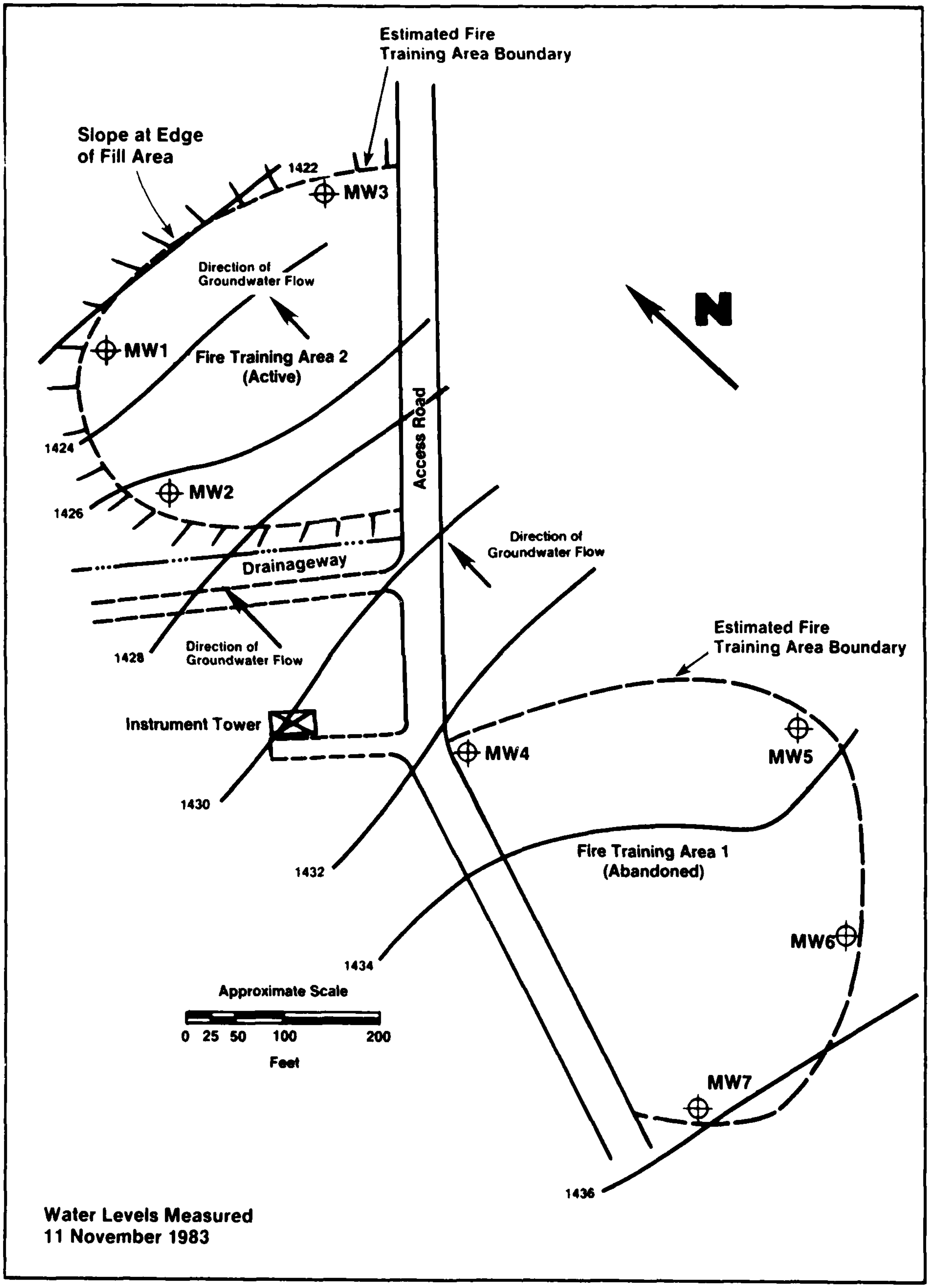

FIGURE 4-1 WATER TABLE MAP FOR FIRE TRAINING AREAS FT-1 AND FT-2

$$i = \frac{\Delta h}{L}$$

where i = hydraulic gradient
h = change in head
L = length of flow

As indicated by Figure 4-1 the direction of flow is toward the north across the fire training sites. As discussed in Section 4.2, the major flow is in the upper part of the groundwater table. Therefore, the groundwater and associated contaminants largely discharge to wetlands to the north of the site and eventually to drainage ways emptying into Wild Rice Lake. The wetlands are, in fact, an expression of the high water table. Although the groundwater flow direction in the area where the wells are located is to the north, the ground surface to the south of the wells slopes to the south toward the runway. The groundwater surface, which is close to the ground surface, should also slope to the south. Since this is not the condition shown on Figure 4-2, WESTON interprets this to mean that a groundwater divide exists to the south of and probably close to the FT-1 monitoring wells.

The velocity of groundwater flow at the site can be calculated from the relationship:

$$v_s = \frac{Ki}{n}$$

where v_s = groundwater seepage velocity
K = hydraulic conductivity
i = hydraulic gradient
n = effective porosity of the sediments

Using an estimated permeability for silty sand of $K = 10^{-4}$ cm/sec or 103 ft/year (Todd, 1964); a hydraulic gradient[1] = 0.02; and an estimated porosity n = 0.3, then solving for velocity:

$$v_s = \frac{(103 \text{ feet/year})(.02)}{.3}$$

$$v_s = 6.9 \text{ feet/year.}$$

---

[1] i - using w2 and w4 which are located along a primary flow vector. $i = \frac{\Delta H}{x} = \frac{6.7'}{400'} = .017 \sim .02.$

ΔH = head difference. x = distance between wells.

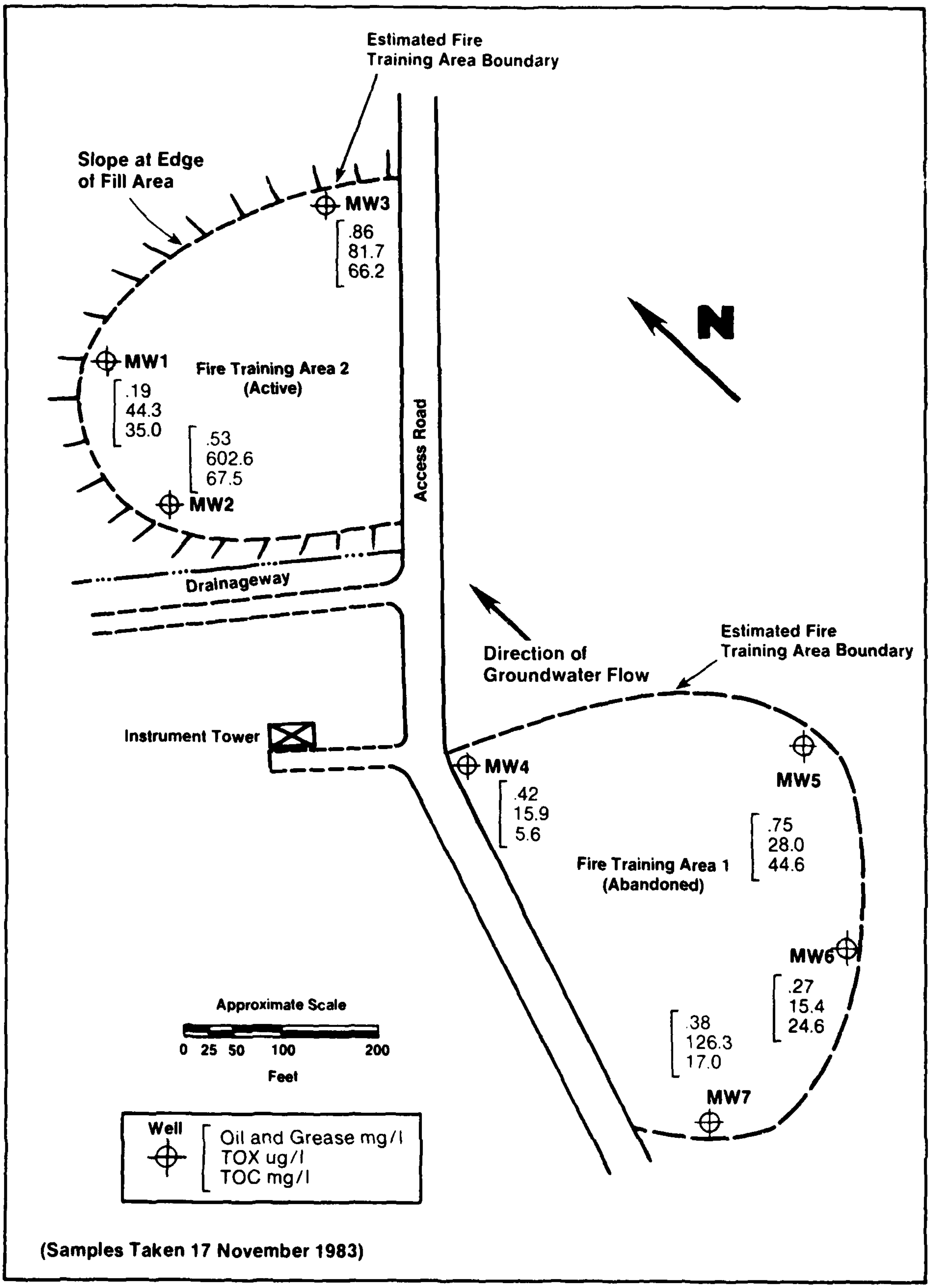

FIGURE 4-2 CONTAMINANT DISTRIBUTION MAP, FIRE TRAINING AREA, DIAP

While only a rough estimate, the above calculations indicate that the velocity of groundwater flow is on the order of 10 feet per year in the water table below the Fire Training Areas.

4.2.1.2 Groundwater Quality

Groundwater samples were taken from all seven Fire Training Area wells according to procedures described in Appendix E. Samples for analysis of TOC, TOX, and nitrates were taken on 17 November 1983. Samples for oil and grease were taken on 5 January 1983. Samples from each well were tested in the field for temperature, pH, and specific conductance. The results of the laboratory analyses and field tests are presented in Table 4-1. Measurable levels of all parameters were found in all of the wells. Figure 4-2 illustrates the spatial distribution of the detected contaminant concentrations associated with wells across the site. Although wells MW-6 and MW-7 are hydraulically upgradient of the other wells (see Figure 4-1), contaminant levels are at or above the other wells. There is, therefore, no well that demonstrates what would be considered background water quality, and all the wells on both Fire Training Area sites apparently lie within the field of contamination. The distribution of contaminants across the site reflects sources distributed throughout the site rather than any single point source. For instance, elevated TOX concentrations at MW-2 (603 ug/l) and MW-7 (126 ug/l) probably indicate the presence of halogenated organic compounds in soils near those wells.

4.2.2 Fuel Storage Area (Site SP-1)

4.2.2.1 Groundwater Flow

Figure 3-7 shows the preliminary field-contoured water table map developed from the water table elevations obtained on 27 October 1983 (summarized in Table 3-4) from the 20 temporary well points and a number of drainage ditch locations. WESTON used a Tektronix computer-graphic system to develop the contour solutions for these elevation points. It is apparent from the data that the groundwater table does not have a simple one-directional flow gradient and a contour map of the water table is fairly complicated. It is possi-

TABLE 4-1

WATER QUALITY RESULTS
FIRE TRAINING AREAS

Well No.	Oil and Grease (mg/l)	TOX (ug/l)	TOC (mg/l)	Nitrates (mg/l)	Temp (C°)	pH	Specific Cond. (umhos-cm)
MW-1	0.19	44.3	35.0	0.48	9	7.08	816
MW-2	0.53	602.6	67.5	0.55	6	7.10	820
MW-3	0.86	81.7	66.2	0.93	9	6.91	1107
MW-4	0.42	15.9	5.6	0.39	5	7.10	574
MW-5	0.75	28.0	44.6	0.35	9	7.40	360
MW-6	0.27	15.4	24.6	0.38	7	7.30	636
MW-7	0.38	126.3	17.0	0.47	7	7.50	657
Detect. Limit	0.1	5.0	1.0	0.1	--	--	--

ble to understand groundwater flow at the site by breaking it down into several elements. These include the following:

- The flow in the drainageways is continuous with the groundwater table. The water in the drainageways, which flows to the west, is a discharge line for the water table.

- Groundwater flow in the storage tank and loading areas radiates outward toward the drainageway discharge line that practically surrounds the site. The discharge line includes the buried culvert on the southwest side of the site (test pit 1) where the backfill soil running along the pipe provides a discharge point because of its relatively higher permeability.

- As indicated by the relative groundwater elevations of three well points on the outside perimeter of the site, the general horizontal gradient and direction of flow for groundwater is southeast to northwest.

Figure 4-3 shows the water table map contoured from the monitor well water table elevation data in Table 3-5. This map confirms the general regional flow direction to the northwest in the Fuel Storage Area.

Because of the relatively high permeability of the upper soils at the site in comparison to the clay rich subsoils, and the proximity of a line of groundwater surface discharge, the path of most surface infiltration to the groundwater is horizontal. Light floating contaminants such as fuel oils tend to travel on the groundwater surface and discharge to the surface drainageways. This discharge is evident in the drainageways at the site, where oily seepage is visible. The rate of migration of potential contaminants from the point of introduction into the fill material toward discharge points along the surface drainageways is expected to be faster than the seepage velocity estimated for the Fire Training Areas. However, due to the presence of fill materials of highly variable composition and degree of compaction, and due to the presence of buried facilities under the site, the magnitude of this migration rate cannot presently be estimated.

4.2.2.2 Groundwater Quality

Based on field observations made at the Fuel Storage Area during exploratory drilling, free-floating fuel oils are

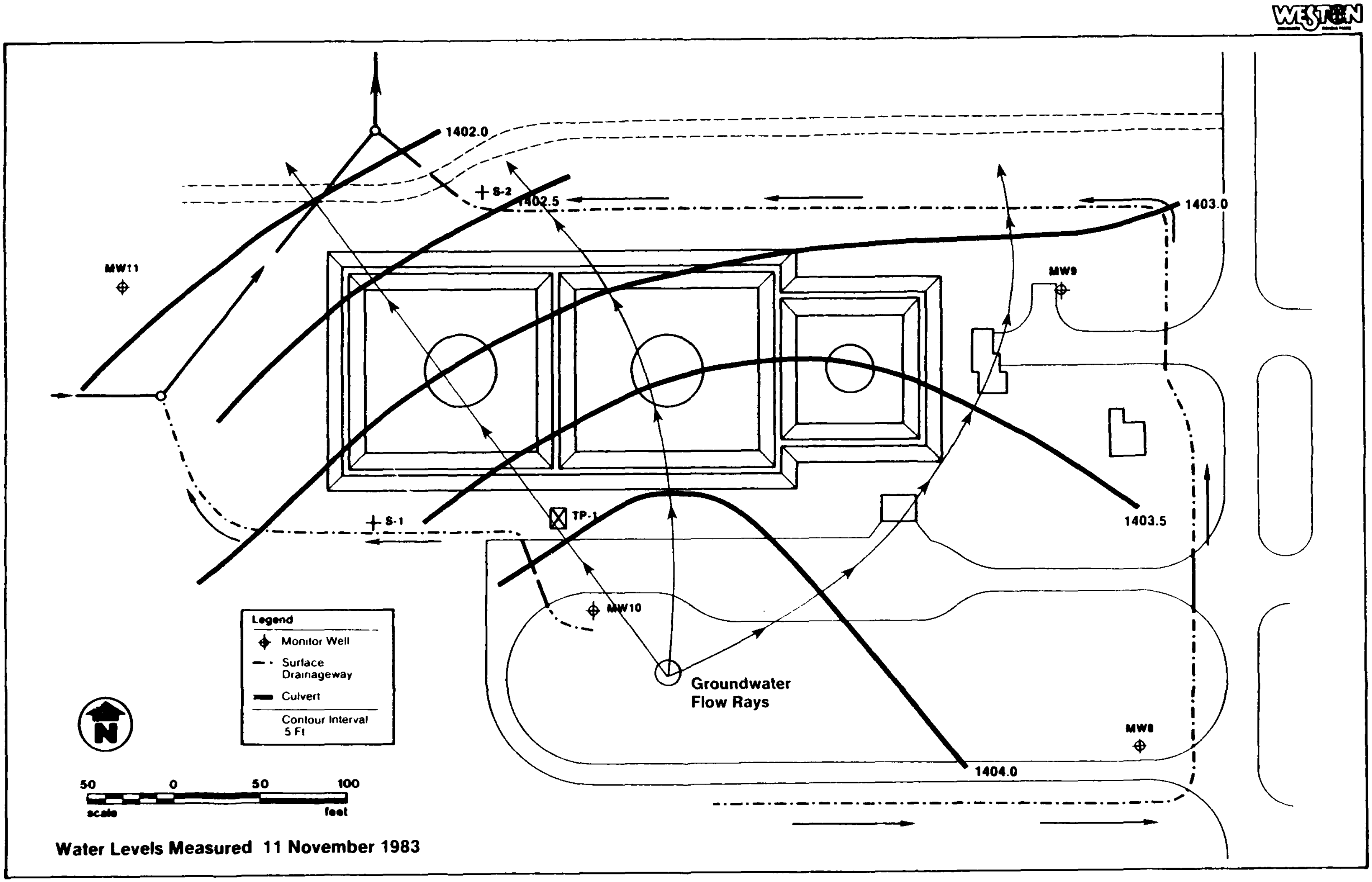

FIGURE 4-3 WATER TABLE MAP FOR THE FUEL STORAGE AREAS

present in the soils and groundwater. Its distribution indicates that rather than caused by a single spill or leak, the contamination is more likely due to the accumulation of small leakages over the history of the facility. The extent of free-floating fuel on the groundwater surface is limited to the immediate area of the storage tanks and truck loading dock. The monitoring wells were purposely set back from the obviously contaminated areas and none of them had free floating fuel or obvious odors when sampled.

Water samples were taken at the site from the 4 monitor wells, Test Pit TP-2 (TP-1 was dry), and 2 surface drainageway locations. All samples were analyzed for oil and grease, lead and total organic carbon. Table 4-2 presents the results of these analyses. As a point of reference, the sample from test pit 2 is from the area previously reported by DIAP as containing fuel oil contamination. The sample itself was an emulsified mixture of fuel oil and water and the levels found of oil and grease at 3,240 mg/l and lead at 31.0 ug/l are representative of the highest levels of contamination at the site.

Oil and grease was found in the upgradient (MW-8) well at a concentration of 0.36 mg/l, and was not found at all in the downgradient well, MW-11. Concentrations in Monitor Wells MW-9 and MW-10 were 1.46 and 49.8 mg/l respectively. It is not surprising to find contaminants in Monitor Well MW-8 because fuel loading activities were conducted in the past along the main road which is upgradient of the fuel storage area. (This fact was brought to WESTON's attention by site personnel after the well installation.) In contrast, the absence of oil and grease in MW-11 may indicate that the buried culvert, between the site and the well MW-11, intercepts the movement of fuel contaminants in the groundwater as discussed in Section 4.2.2.1 above. Although oil and grease concentrations in MW-10 are high, they are much lower than those found in Test Pit TP-1, which is less than 100 feet away. No free floating fuel oil was observed in MW-10 or any other well at the time of sampling.

Oil and grease concentrations in the surface water samples 1 and 2 were 0.5 and 20.8 mg/l respectively. These are within the range of values found in the monitoring wells. Sample 1 was taken from the ditch that drains the loading area. Near the loading area itself, the ditch water had a film of oil on its surface. Sample 2 was taken directly opposite a culvert opening where the water exits the site. An oily film was observed in the water and on seepage from the ditch bank.

TABLE 4-2

SUMMARY OF WATER QUALITY RESULTS
FUEL STORAGE AREA, DIAP
SAMPLED 15 NOVEMBER 1983

	TOC (mg/l)	Oil & Grease (mg/l)	Pb (mg/l)	Temp.[1] (C°)	pH[1]	Specific[1] Conductance μmhos/cm
Monitoring Wells						
MW-8	49.3	0.36	< .020	8°	6.90	578
MW-9	70.0	1.46	< .020	5°	7.25	782
MW-10	49.0	49.80	< .020	8°	7.18	608
MW-11	17.0	< .10	< .020	8°	6.55	716
Test Pit 2	140	3240	0.031			
Drainage S-1	<1.0	47.20	< .020			
S-2	20.5	48.00	< .020			
Detection Limits	1.0	.10	< .020			

1 - Determined in the field at time of sampling

4.3 SURFACE WATER AND SOIL CONDITIONS

4.3.1 Goose Missile Site Disposal Area (Site D-1)

A total of 11 soil samples and 8 water samples were analyzed by WESTON's laboratory. All samples were analyzed for pesticides; the water samples were also analyzed for total organic carbon and total organic halogens. A PCB compound (Arochlor 1260) was also detected on the pesticide analysis, as the analytical methods are the same. The results of these analyses are presented in Table 4-3. The pesticide concentration distribution in the sediments is graphically shown on Figure 4-4. Based on these results, the following observations are made:

1. The pesticide compound DDD was the only pesticide compound detected in these samples, and it was found in all sediment samples taken within the pond. No pesticides were found in the inflow drainageway (sample 10) or in the furthest outflow drainageway sample (sample 11). Relatively low levels of pesticides were found in the near outflow drainageway sample (sample 5).

2. The range of DDD in the nine sediment samples where it was found was from .001 to .215 ug/g.

3. Of the 8 surface water samples taken, only one sample (sample 6) contained pesticides, in detectable concentrations (less than 0.2 ug/l). This sample was collected in close proximity to a barrel in the pond.

4. Total organic carbon (TOC) concentrations in water samples ranged from 8.8 to 11.5 mg/l and total organic halogens (TOX) ranged from 5.9 to 29.1 ug/l. Background levels for these parameters in surface water around DIAP were not established. The above values for TOC are to be expected in a marshy area such as this.

5. The analysis for pesticides also showed levels of the PCB Arochlor 1260 in some samples. These results are also shown on Table 4-3. Because of the overprinting of key analytical peaks, the

TABLE 4-3 SUMMARY OF SURFACE WATER AND BOTTOM SEDIMENT ANALYTICAL DATA GOOSE MISSILE SITE DISPOSAL AREA (Sampled 16 November 1983)

Sampling Location	BOTTOM SOIL SAMPLES Pesticides in Soils		SURFACE WATER SAMPLES Pesticides in Water		TOC	TOX
	D.D.D. (µg/g)	Arochlor-1260[1] (µg/g)	D.D.D. µg/l	Arochlor-1260[1] µg/l	mg/l	µg/l
1	0.139	0.450	<0.1	<0.1	10.9	12.6
2	0.112	0.070	<0.1	<0.1	8.8	11.0
3	0.092	0.360	<0.1	<0.1	9.7	13.9
4	0.100	1.200	<0.1	<0.1	9.7	5.9
5	0.001	0.020	.... D R Y			
6	0.215	1.300	0.18	0.2	11.5	24.1
7	0.132	0.320	<0.1	<0.1	11.0	16.5
8	0.016	0.080	<0.1	<0.1	8.85	< 5.0
9	0.056	0.160	<0.1	<0.1	10.7	29.1
10	0.001	0.010	.... D R Y			
11	0.001	0.010	.... D R Y			
Detection Limit	0.001	0.010	0.1	0.1	1.0	5.0

NF = Not Found

[1] PCB compound detected in pesticide analysis by EPA Method 608

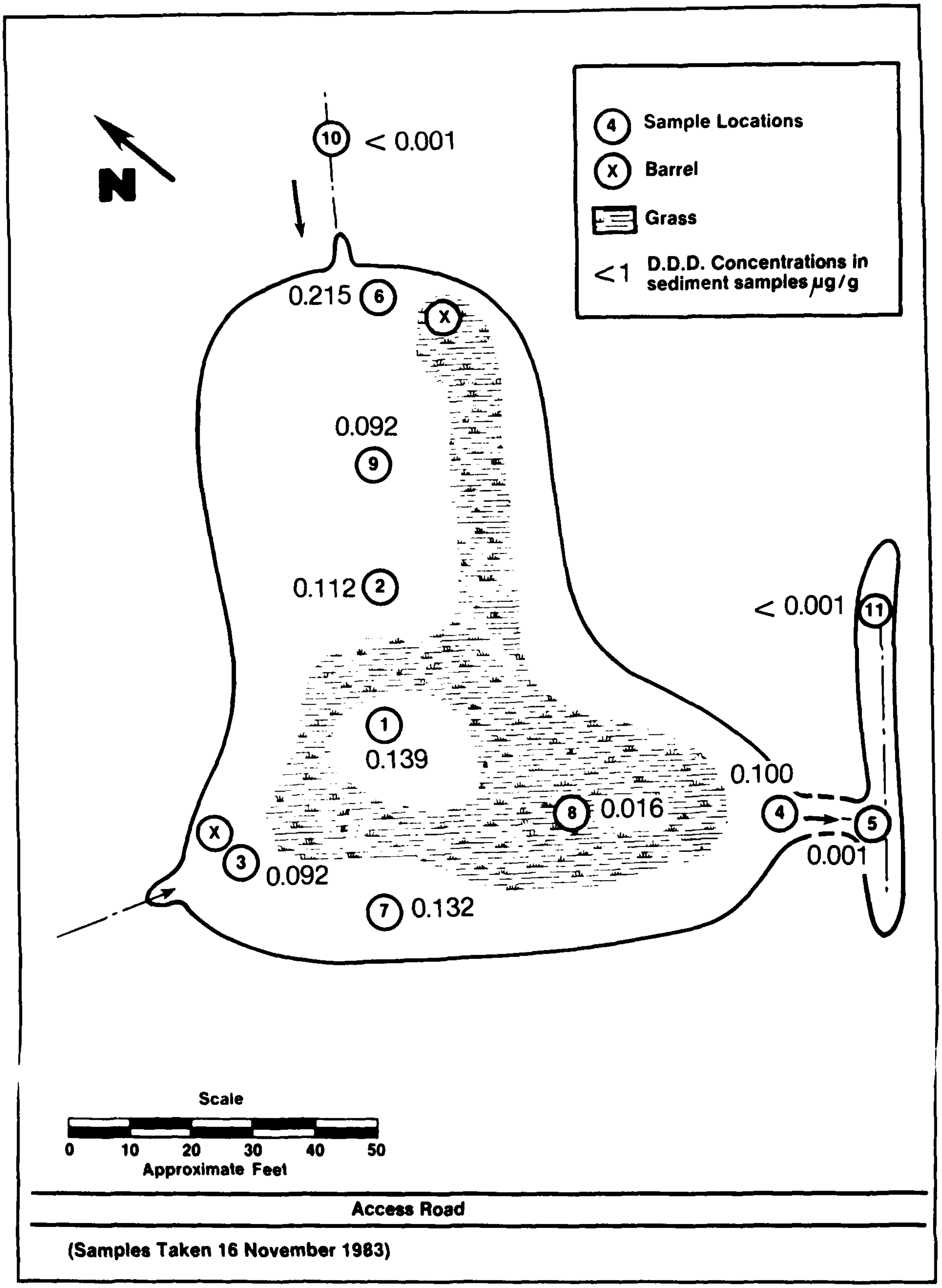

FIGURE 4-4 SPATIAL DISTRIBUTION OF DDD IN BOTTOM SEDIMENTS, GOOSE MISSILE SITE DISPOSAL AREA

presence of this compound may have interfered with the detection of DDT and breakdown products DDE and DDA. Since DDD is a breakdown product of DDT, these compounds are usually found in association with one another.

6. Inflow to and outflow from the pond is intermittent and no flow was observed during the investigation. The pond outflow drainageway enters a deeper ditch which in turn has no obvious outflow. If contaminated soils were transported from the pond in times of high water, the drainageway would act as a settling pond and the sediments would be trapped. In fact, there appears to be negligible migration of soil from the pond. The drums observed in and around the pond were empty and deteriorated cardboard and metal containers and any contents were already dispersed.

4.3.2 DPDO Storage Area "C" (Site S-1)

4.3.2.1 Analytical Results

Two bottom sediment samples from the adjacent drainageway and the 20 soil samples recovered from boring intervals zero to 1 and 1 to 2 feet in the 10 soil exploratory borings were submitted to WESTON's Laboratory for analyses of oils and greases, and USEPA Priority Pollutant List Volatile Organic Compounds (VOA). The results of the analyses of these samples are presented in Table 4-4. Figure 3-5 illustrates the sample locations. The high levels of oil and grease found in most of the samples confirms the field observation that oily products have obviously seeped onto a large portion of the ground surface. Oil and grease concentrations decrease rapidly with depth but are still high in the deeper samples.

Volatile organic compounds were found in the two drainageway soil samples and in all but two of the exploratory boring samples. A total of 11 compounds were found in the samples. The most common organic compound was chloroform (found in 13 of the samples). The most concentrated compound detected was trichloroethane at .940 ug/g in the 1 to 2 foot sample of boring C-1. Five VOA compounds were found in soils off-site in the drainageway sediments. In general the variety of compounds and the scattered occurrence of individual compounds throughout the site indicates the local occurrence of leaks associated with the storage of drums of diverse materials at the site.

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TABLE 4-6 SUMMARY OF SOIL CHEMISTRY DATA
DPDO STORAGE AREA "C"

	Depth (in ft.)	Oil and Grease ug/gm	Chloro-form ug/gm	Trichloro-ethylene ug/gm	1,1,1-Trichloro-ethane ug/gm	Bromodi-chloro-methane ug/gm	Dibromo-chloro-methane ug/gm	Tetra-chloro-ethylene ug/gm	Trans-1,2-Dichloro-ethylene ug/gm	1,2-Dichloro-ethane ug/gm	1,1-Dichloro-ethylene ug/gm	1,1-Dichloro-ethane ug/gm
C-1	0-1	16,700	0.025	--	0.011	--	--	--	--	--	--	--
	1-2	16,700	--	--	--	--	--	--	--	--	--	--
C-2	0-1	23,400	0.120	--	--	0.001	--	--	--	--	--	--
	1-2	5,700	--	--	--	--	--	--	--	--	--	--
C-3	0-1	23,400	--	--	--	--	--	--	--	--	0.006	--
	1-2	5,600	0.047	--	--	--	--	0.002	--	--	--	--
C-4	0-1	35,400	0.315	0.003	0.003	0.008	--	0.001	--	--	--	--
	1-2	14,500	0.066	--	--	--	--	--	--	--	--	--
C-5	0-1	13,400	0.076	0.210	--	--	--	--	--	--	--	--
	1-2	3,660	0.048	0.940	--	--	--	--	--	--	--	--
C-6	0-1	41,800	0.061	0.002	0.011	--	--	0.300	--	--	--	--
	1-2	13,400	0.073	--	0.210	--	--	0.220	--	--	--	--
C-7	0-1	40,600	0.055	--	--	--	--	--	0.006	--	--	--
	1-2	13,100	0.018	--	--	--	--	--	--	--	--	--
C-8	0-1	49,500	--	--	--	--	--	--	--	--	0.015	--
	1-2	16,900	--	--	0.014	--	0.003	--	--	--	--	--
C-9	0-1	7,325	--	--	--	--	--	0.001	--	0.003	0.032	0.012
	1-2	243	--	--	--	--	--	--	--	0.018	0.037	0.013
C-10	0-1	194	--	--	--	--	--	--	--	0.003	0.015	0.022
	1-2	161	--	--	--	--	--	--	0.014	0.003	0.012	0.007
S-1	0-.5	11,000	0.240	0.140	0.001	0.016	--	--	0.500	--	--	--
S-2	0-.5	3,470	0.220	0.020	0.001	0.006	--	--	--	--	--	--
Detection Limits		0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

-- Below minimum detection limit.

4.4 SIGNIFICANCE OF FINDINGS

4.4.4 Water Quality - General

The principal objective of the Phase II Confirmation Study was to determine whether past hazardous waste operations or disposal practices had resulted in environmental degradation. The analytical results of the Phase II study represent a single round of sampling at selected surface water quality stations and newly installed monitor wells. The conclusions drawn from this information should be evaluated with this understanding.

Groundwater and surface water quality results are in Tables 4-1, 4-2 and 4-3. Appendix I includes all analytical results from monitoring the four sites. Appendix I contains a complete listing of Federal and State drinking water and human health standards, criteria and guidelines applicable in the State of Minnesota.

On November 28, 1980, the U. S. Environmental Protection Agency issued criteria for 64 toxic pollutants or pollutant categories which could be found in surface waters. The criteria established recommended maximum concentrations for acute and chronic exposure to these pollutants and both human and aquatic life. The derivation of these exposure values was based upon cancer risk, toxic properties, and organoleptic properties.

The limits set for the cancer risk are not based upon a safe level for carcinogens in water. The criteria state that for maximum protection of human health, the concentration should be zero. However, where this cannot be achieved, a range of concentrations corresponding to incremental cancer risks of from 1 to 10 million to 1 in 100,000 was presented (10^{-7} to 10^{-5}).

Toxic limits were established at levels for which no adverse effects would be produced. These are the health related limits which have been used in this report to evaluate potential impacts. It should be noted that the cancer risk column is based upon one cancer case in one million, (10^{-6}). The EPA's evaluation criteria under CERCLA (Annex XIII) for selecting contaminant levels to protect public health call for the remedial action to "attain levels of contamination which represent an incremental risk of contracting cancer between 10^{-5} and 10^{-6})". The 10^{-6} value

was used to achieve the maximum protection to the public.

In addition to the cancer risk assessment criteria, the U.S. EPA Office of Drinking Water provides advice on health effects upon request, concerning unregulated contaminants found in drinking water supplies. This information suggests the level of a contaminant in drinking water at which adverse health effects would not be anticipated with a margin of safety; it is called a SNARL (Suggested No Adverse Response Level). Normally values are provided for one-day, 10-day and longer-term exposure periods where available data exists. A SNARL does not condone the presence of a contaminant in drinking water, but rather provides useful information to assist in the setting of control priorities in cases when they have been found.

SNARLs are not legally enforceable standards. They are not issued as an official regulation, and they may or may not lead ultimately to the issuance of a national standard or Maximum Contamination Level (MCL). The latter must take into account occurrence and relative source contribution factors, in addition to health effects. It is quite conceivable that the concentration set for SNARL purposes might differ from an eventual MCL. The SNARLS may also change as additional information becomes available. In short SNARLs are offered as advice to assist those who are dealing with specific contamination situations to protect public health.

The above information concerning SNARLs was taken directly from guidance documentation authorized by the EPA and made available to WESTON. The SNARLs levels for various compounds were also used in evaluating the results of ground and surface water sampling.

4.4.2 Water Quality at DIAP

There are very few water quality sampling guidelines or criteria which apply to the limited suite of analytes used for water quality analysis during the Phase II Confirmation Study. Table 4-5 summarizes those which do apply, and indicates the monitoring points which exceed the standard guideline or criterion shown. The most common contaminant noted is oil and grease which exceeded the aesthetic criterion in all monitor wells and surface water sampled. Lead analyses on monitor well samples from the Fuel Storage Area were all above Federal and State Water Quality Standards. Only one surface water sample at the Goose Missile Site Disposal Area

TABLE 4-5

COMPARISON OF DIAP WATER QUALITY RESULTS WITH APPLICABLE STANDARDS, GUIDELINES AND CRITERIA [1]

Detected Paramters	Drinking Water Standards Minnesota and Federal	Quality Criteria for Water	Monitoring Points Exceeding Standard
TOC	-	-	-
TOX	-	-	-
OIL & GREASE	-	0.01 [2]	ALL
LEAD	0.05 [3]	0.05 [3]	NONE
DDD	-	0.000[3]	SW-6[4]
NITRATE	10.0	-	NONE
SPECIFIC CONDUCTANCE	1000 [5]	-	MW-3

1 mg/l unless otherwise noted.

2 Virtually free of oil and grease for domestic water supply.

3 Health related.

4 Surface Water sample No. 6, Goose Missile Site Disposal Area.

5 u mhos/cm, Wildlife related.

exceeded the fresh water aquatic life guideline for DDD, and this sample was obtained in close proximity to a barrel of unknown contents.

The major potential problem indicated by the data available is that of halogenated organic compounds (TOX) detected in the Fire Training Area monitoring wells. All groundwater samples tested for TOX contained concentrations in excess of 15 parts per billion (ppb) and 2 wells exceeded 100 ppb. Specific halogenated organic compounds should be identified during IRP Phase II, Stage 2 work, since standards exist or are proposed for some of these compounds. Specific halogenated organic compounds should also be identified at the Goose Missile Site, since TOX valued over 29 ppb were detected.

4.4.3 Soil Quality at DIAP

There are no current quality standards, guidelines or criteria for the majority of soil contaminants. Target concentrations for various compounds in soils are usually established on a case-by-case basis by the regulatory agency having jurisdiction, and these target concentrations are usually established for attainment purposes in cleanup of environmental contamination.

The DDD pesticide levels in bottom sediments from the Goose Missile Site Disposal Area are not viewed by WESTON as an indicator of a major environmental problem--DDD has a very low aqueous solubility, and very low concentrations in soils taken from the outflow ditch indicate that DDD compounds are exiting the disposal site at very low concentrations, if at all. However, the presence of PCB's in these sediments is also a potential concern although the potential for migration of this substance in groundwater is very low. Action limits regarding PCB contamination in soils have not been finally established by USEPA or state agencies as of this writing. Bottom sediments at Goose Missile site pond should be re-sampled to quantify the extent of pesticide and PCB contamination.

Soils at the DPDO Storage Area "C" were shown to be contaminated with a selection of VOA compounds from the USEPA Priority Pollutant List. While soil concentrations were relatively low in most cases, the potential for groundwater contamination exists.

4.4.4 Conclusions

Based upon the results of the Phase II Confirmation Study at DIAP, the following key conclusions have been drawn:

General

1. Groundwater occurs under shallow water table conditions in and around all sites investigated. Lateral groundwater gradients typically average about 0.02, reflecting the glacial materials present. Groundwater seepage velocities are generally low on the order of ten feet per year, in the low permeability sediments.

2. Regional water table flow is generally northerly, as determined at the Fire Training Areas and the Fuel Storage Area. Locally, however, this regional gradient is modified by surface drainageways which intercept the upper few feet of water table flow. Water table discharge of shallow contaminants to these surface drainageways is the dominant factor in rapid off-base migration of potentially hazardous contaminants from all sites evaluated.

3. The potential for off-base migration of contaminants is demonstrated by detection of solvent compounds in the surface drainageway adjacent to the DPDO Storage Area "C" and by observation of oily discharges in surface drainageways adjacent to the Fuel Storage Area.

Goose Missile Site

Part-per-billion level concentrations of the pesticide DDD were found in the bottom sediments of the Goose Missile Site Disposal Area. However, off-site migration of pesticides in water or sediments appears to be negligible. A non-pesticide compound, identified as PCB, was detected in those sediments in the same general distribution as the pesticide.

Fire Training Areas

The groundwater flow direction across the Fire Training Areas is to the north at a rate estimated to be on the order of 10 feet/year. Based upon topography, it is likely that a groundwater divide exists to the south of the well network,

in the direction of the runway. Elevated concentrations of TOC, TOX, and oils and grease were found in all seven wells. The distribution of contaminant levels reflects the dispersed nature of contaminated soils which are affecting groundwater quality. Although the extent of soil contamination of the FT-1 site is unknown, its boundary probably extends beyond the area outlined by the well network including MW-4 through MW-7. Discharge of shallow groundwater to these surface drainageways creates a potential for off-base migration of contaminants.

DPDO Storage Area "C"

There is measurable contamination of soils on the DPDO Storage Area "C" by oil and grease compounds and by volatile organic compounds. This contamination extends at least two feet deep at the site and is distributed throughout the site. In two soils samples in the drainageway, levels of oil and grease and volatile organic compounds were found comparable to levels in on-site soils. This may indicate that off-site erosion of contaminated soils is occurring or that direct spillage to the ditch has occurred. There is also a potential for contaminants to dissolve and to migrate to the water table and then to surface drainageways which flow to Beaver Creek, a tributary to Wild Rice Lake.

Fuel Storage Area

Free-floating fuel oil was observed in soil borings test pits and drainage water in the immediate vicinity of the Fuel Storage Area. The source of the contamination is likely to be chronic leakage from the storage tanks and transmission lines over the history of the facility. The groundwater surface around the entire site is intercepted by surface drainageways or buried culverts which act as discharge lines for the upper several feet of the groundwater table and contaminants that may be floating on it. Contaminants from the groundwater are entering the surface drainage system adjacent to the site, and then discharging directly to Beaver Creek. Although the extent of contamination in the groundwater around the fuel storage area is limited in area, an immediate avenue is available for discharge of contaminants into surface drainageways and migration off-site.

SECTION 5

ALTERNATIVES

5.1 GENERAL

The principal goal of the Phase II Confirmation Study at DIAP was to determine whether or not environmental degradation was occurring as the result of past practices of materials handling or disposal at DIAP. The conclusions presented in Section 4 confirm that each of the four sites investigated have affected groundwater, surface water or soils in their immediate area. These findings are based upon a single set of analyses, which require additional verification. Further sampling is recommended for Stage 2.

The alternative measures discussed below focus mainly upon problem definition aspects of environmental contamination detected at Duluth IAP. These alternative measures are discussed by site in the following sections. Based on possible alternatives discussed here, specific recommendations are presented in Section 6.

5.1.1 Goose Missile Site Disposal Area (Site D-D) - Alternative Measures

Since pesticide contamination appears to be limited to the pond itself further surface water or sediment sampling would not necessarily be justified. However, the non-pesticide organic peaks that were noted in the first round of samples and identified as PCB should be verified.

5.1.2 Fire Training Area (Sites FT-1 and FT-2 - Alternative Measures

Since all of the existing wells at the fire training area contain similar levels of contaminants, additional wells will be needed to define the extent of contaminant migration in the groundwater. A quantification stage analyses should be performed on samples from the existing monitoring wells to determine key indicators to be used when sampling the expanded well network. The extent of contaminated soil associated with Site FT-1 should also be determined by sys-

tematic sampling of surface and near surface soils. Since the possibility exists for the erosional transport of contaminated soils off-site, soils should be sampled in drainageways adjacent to the site.

5.1.3 DPDO Storage Area "C" (Site S-D) - Alternative Measures

Since the presence of contamination has been confirmed to a depth of at least 2 feet below the surface of the site, additional analyses should be performed for similar parameters for samples presently in storage that were collected at depths of from 2 to 5 feet. Because of the long holding time, quality assurance requirements would not allow confidence in quantitative results; however, qualitative results would be useful. Further off-site soil sampling should also be performed to identify the extent of transport of contaminated soils in the drainageway adjacent to the site. Because infiltration from the site to the groundwater table is possible, groundwater monitoring wells are needed to assess the potential for groundwater contamination.

5.1.4 Fuel Storage Area (Site SP-1) - Alternative Measures

It is evident from soil borings near the tank farm berms and truck loading areas that there is fuel oil contamination in the subsoil and on the surface of the groundwater table. The extent of this contamination should be identified by additional soil borings and monitored by additional well points.

The existing monitoring wells and surface water sampling points should be resampled on a routine basis for analyses of oil and grease and lead in order to better identify the trend in upgradient and downgradient groundwater quality. In addition, the type of petroleum product or products should be identified in order to better identify the source. Upstream sampling and analysis should also be conducted to establish background quality for surface waters relative to the Fuel Storage Area.

Because the fuel oil contamination was observed in a limited area close to the ground surface, product recovery may prove a viable remedial action alternative. The investigation should identify, where practical, the extent of free floating contamination on the groundwater surface. This can be done with additional soil borings and backhoe pits. Similar

attention should also be given to the abandoned site of the fuel loading area that was located in the past along the main road to the north of the site. This loading area was connected to the tank farm by buried pipes which are still in place. Before any additional investigation, the location of buried lines indicated on plant drawings should be confirmed by a geophysical survey.

5.2 SUMMARY

Supplementary off-site actions concerning water resource analysis and monitoring are not believed to be necessary yet based on the data obtained to date. They are included in the alternative measure category in the event that substantial migration of contaminants is detected in subsequent monitoring. Section 6 contains specific recommendations for future Quantification Stage actions.

SECTION 6

RECOMMENDATIONS

6.1 GENERAL

The findings of the Phase II Study at four sites on DIAP indicate the need for follow-on work. This work includes the following:

1. General verification of the initial round of water quality sampling and analyses.

2. An expanded monitoring and field sampling program with an emphasis on determining the nature and extent of contamination by priority pollutants.

The recommended actions, discussed by site, are intended to establish the data base for evaluation of what, if any, remedial actions might be necessary for each given site. The recommendations are presented in prioritized order. The recommendations are summarized in Table S-1.

6.1.1 Goose Missile Site Disposal Area (Site D-D) - Recommendations

The following additional work is recommended for the Goose Missile Site Disposal Area, based upon the results obtained to-date.

1. Additional bottom sediment samples should be obtained from the bottom of the pond, concentrating on previous sampling locations 1, 4, 6, and 7. The purpose of these samples is to evaluate the magnitude of DDD contamination in the pond in the vicinity of the highest concentrations found to-date. Analysis of these samples for USEPA Standard Method 608 pesticides will verify the scale of pesticide contamination present. Eight additional bottom sediment samples are recommended for this purpose.

2. These additional eight bottom sediment samples are also recommended to be analyzed for a broad spectrum of PCB Arochlors. Comprehensive sample extraction, cleanup and concentration are recommended, in order to confirm and quantify the presence of PCB

compounds. The concentrated extracts should be subjected to quantitative analysis by gas chromatography with second column confirmation, in order to obtain reliable verification of the presence or absence of PCB at the site. These analyses will also determine whether or not a remedial action is mandated by current policies of the USEPA and the Minnesota Pollution Control Agency (MPCA).

3. Since both pesticide and PCB are only slightly soluble in water, and only a very low concentration of DDD was found in one surface water sample, no further surface water sampling and analysis is recommended.

6.1.2 Fire Training Areas (Sites FT-1 and FT-2) - Recommendations

The following additional work is recommended for the Fire Training Areas, based upon the results obtained to-date:

1. All 7 existing monitoring wells at the Fire Training Areas should be resampled and analyzed to verify the initial sampling results. The analytical protocol should be the same as for the first round (Table 1-2). In addition, an expanded analytical protocol should be adopted for Monitor Well MW-2, which contained the highest TOX and TOC detected in the monitoring well array. This expanded protocol should include USEPA Priority Pollutant List Volatile Organic Compounds (VOA), using Standard Methods 601 and 602, plus phenols compounds.

   The rationale for the additional analysis from the most contaminated well is to establish, with reasonable certainty, the chemical parameters of concern. The resampling and review of results should precede any subsequent on-site work.

2. A series of soil sampling borings is recommended for each of the Fire Training Areas. The purpose of these borings is to ascertain the magnitude and extent of soil contamination present at the sites. A secondary purpose of the borings recommended for the former Fire Training Area (Site FT-1) is to ascertain the boundaries of the area. Figure 6-1 shows candidate sites for nineteen soil exploratory

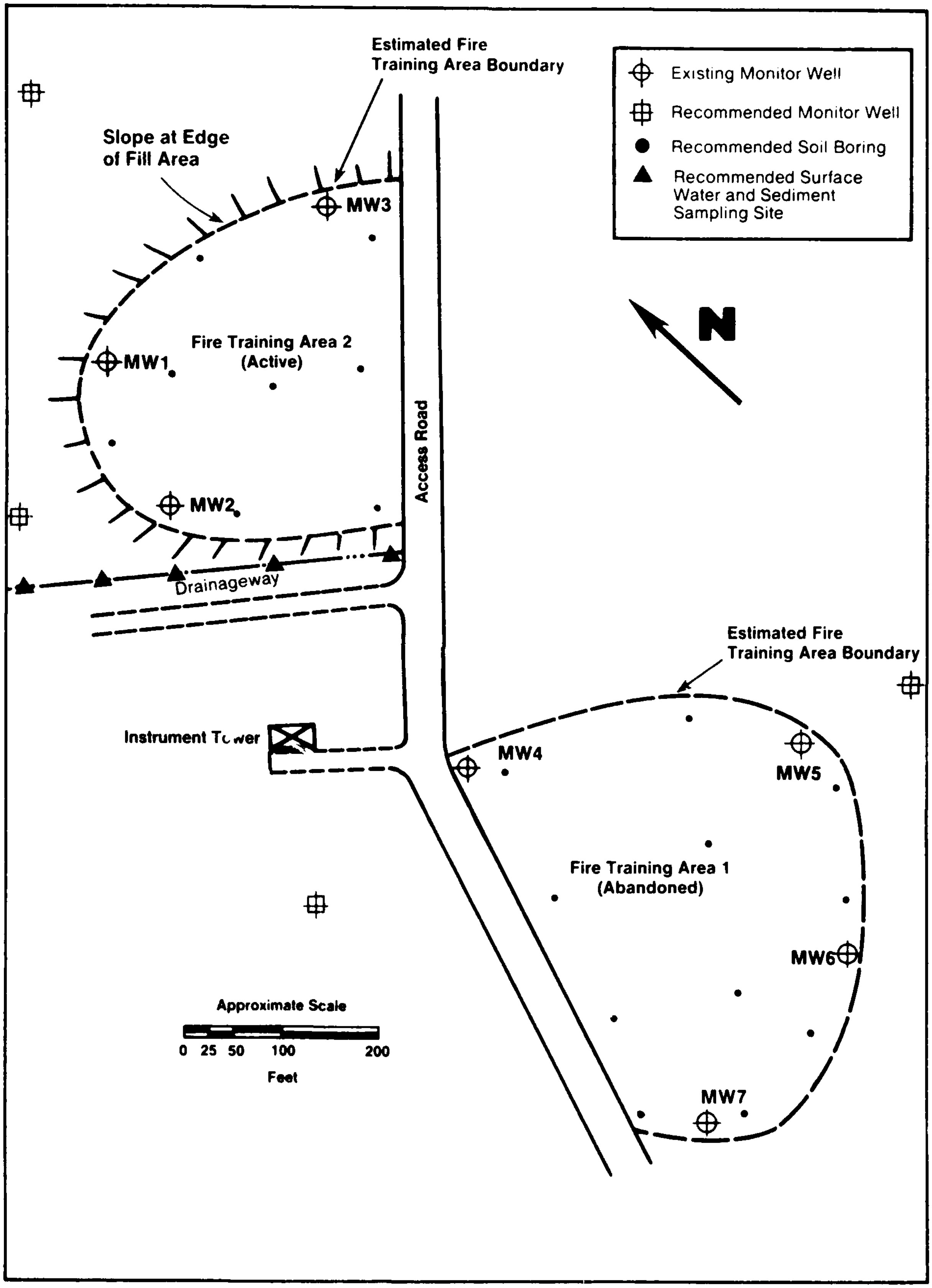

FIGURE 6-1 LOCATIONS OF RECOMMENDED ADDITIONAL MONITOR WELLS, SOIL BORINGS AND SURFACE WATER AND SEDIMENT SAMPLING, FIRE TRAINING AREAS

borings. These borings will be 5 feet deep or less, and can be placed rapidly, so that a large area can be covered at minimal cost and time. The 11 candidate sites shown for Site FT-1 would be drilled starting at the center of the area and monitored with an HNU during drilling--only those borings in which soils exhibited field evidence of contamination would be sampled for laboratory analysis.

3. Additional monitoring to establish the extent of contamination and groundwater quality in an extended area around the sites is recommended following the verification sampling. Until the verification sampling is complete, the precise number and locations of wells is indefinite. Figure 6-1 illustrates four candidate sites for well construction. These locations will enable quantifying the magnitude and extent of contamination. As a preliminary estimate, as many as four additional monitor wells are anticipated to be necessary in order to define the magnitude and extent of groundwater contamination originating at the Fire Training Areas. The number of wells actually installed would depend in part on the soil analysis results.

4. A set of 3 staff gage stations are recommended to be established to monitor surface water and sediments in the drainageway flowing northwesterly from the 2 sites. Samples of surface water and bottom sediments are recommended for analysis from each of these 3 stations.

5. The analytical protocol for groundwater, surface water, bottom sediments and soils would be selected based upon the verification sampling accomplished in Recommendation 1 above. Based upon analytical data available to-date, it appears likely that the USEPA Priority Pollutant List Volatile Organic Compounds (VOA) will be the primary analytes for this evaluation.

6.1.3 DPDO Storage Area "C" (Site S-1) - Recommendations

The following additional work is recommended for the DPDO Storage Area "C", based upon the results obtained to-date.

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1. Because of the positive results obtained from analyses of soil samples collected to a depth of 2 feet, analysis of the remaining soils collected from 2 to 5 feet deep should be conducted. The purpose of these additional analyses is to ascertain the 3-dimensional distribution of VOA and oil and grease contaminants in the unsaturated sediments comprising the storage pad. These samples are presently being stored in WESTON's Laboratory. In addition, 3 more grab samples of sediments from the drainage ditch should be collected for analysis, including one sample at Sample Location 2 (see Figure 4-4) and 2 samples further downstream. The purpose of these additional samples and analyses is to ascertain the degree of downstream migration of contaminated sediments apparently being eroded off-site and into the surface drainageway adjacent to the site. All soil samples should be analyzed for oil and grease and USEPA Priority Pollutant Volatile Organic Compounds (VOA) using Standard Methods 601 and 602.

2. The existence of sediments at the storage area contaminated with VOA compounds indicates the potential for groundwater contamination to occur. WESTON recommends that a single groundwater monitoring well be constructed along the north side of the pad near boring 5 (see Figure 3-5). The well should be constructed in the same manner as the existing wells with 15 feet of screen extending three feet above the water table. Soil samples should be taken at depths of 1, 3 and 5 feet and at the water table in the well boring for analysis of oil and grease and VOA compounds. Groundwater samples from each well are recommended for analysis of USEPA Priority Pollutant List Volatile Organic Compounds (VOA) using Standard Methods 601 and 602, and analysis for oil and grease.

6.1.4 Fuel Storage Area (Site SP-1) - Recommendations

The following additional work is recommended for the Fuel Storage Area, based upon the results obtained to-date.

1. All 4 existing monitoring wells at the Fuel Storage Area should be resampled and analyzed to verify the initial sampling results. The analytical protocol should be the same as for the first round (Table 1-2). In addition, the analytical protocol should be expanded to include the USEPA Priority Pollutants List Volatile Organic Compounds (VOA)

using Standard Methods 601 and 602, plus phenols. The rationale for these additions is that VOA and phenol compounds are sometimes added to fuels to increase BTU values, and that such additives often dissolve in groundwater and migrate at rates independent of floating fuel migration rates. The resampling and review of results should precede any subsequent on-site work.

2. Precise locations of underground pipes and facilities were not able to be determined in some cases from existing facilities maps. Prior to accomplishing the proposed additional drilling a geophysical survey is recommended, in order to locate the facilities in question. The survey area should be expanded toward the main road to the south of the Fuel Storage Area in order to encompass buried pipes connecting the existing tank farm to the formerly operated fueling facility located there. A combined use of ground penetrating radar and magnetometer are recommended with a traverse grid of 25 feet inside the tank farm fence and 50 feet outside the fence.

3. Additional monitoring to establish the extent of contamination and groundwater quality in an expanded area around the site is recommended following the verification sampling. Exploratory drilling detected floating fuel products in the area adjacent to the dikes around the tank facility, and the distribution of this fuel contamination should be determined. Figure 6-2 is a map of the Fuel Storage Area showing recommended locations of twelve additional soil borings to be drilled in order to quantify this problem. Up to four of these borings would be converted to permanent monitor wells--actual borings would be selected for conversion based upon findings in the field. Most of these boring locations were inaccessible during the present study due to the configuration of existing facilities--small scale, portable drilling equipment is recommended for use in drilling these additional borings and wells. Well construction should be the same as that used on existing wells with screen protruding above the water table where possible.

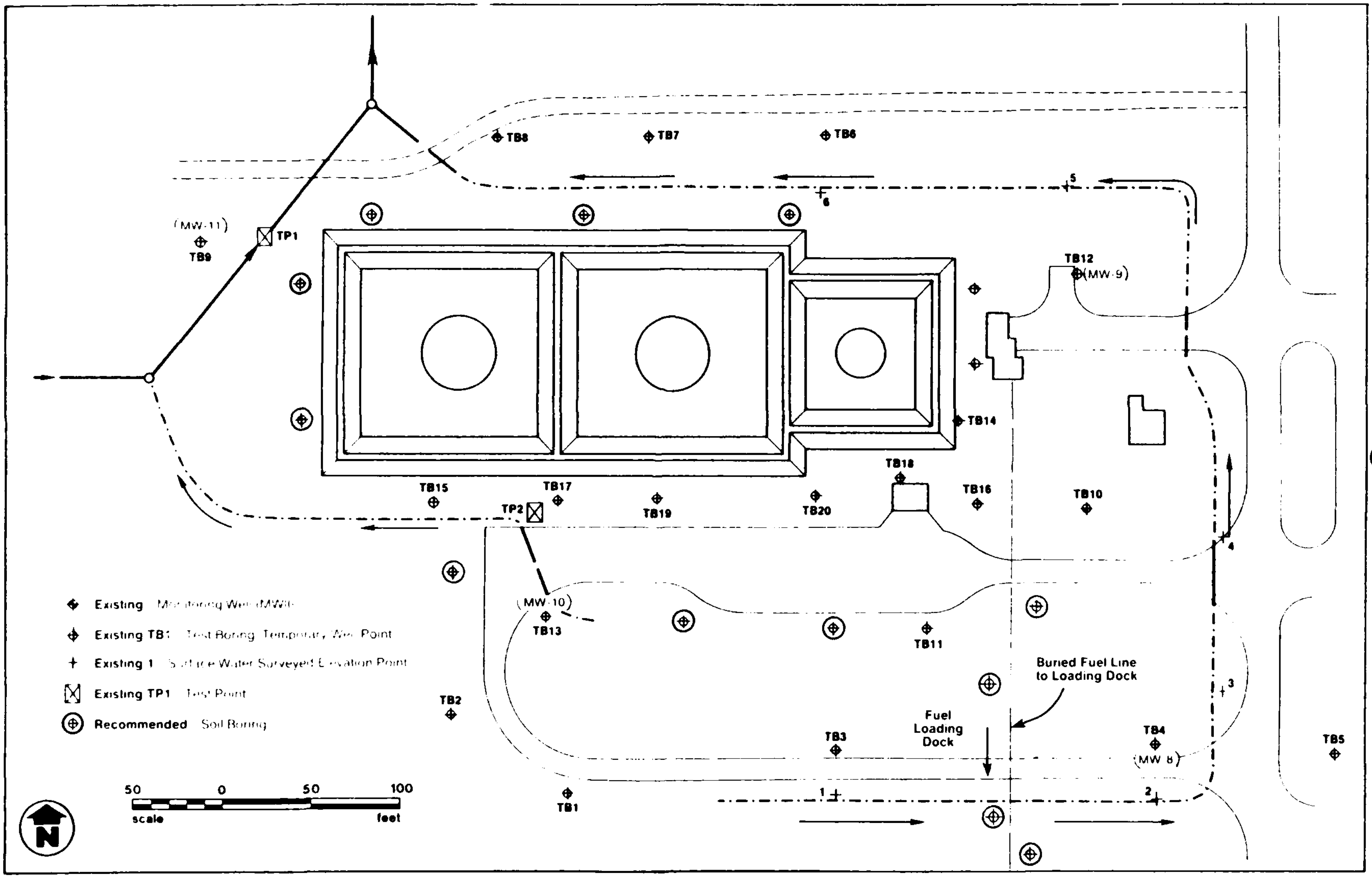

FIGURE 6-2 LOCATIONS OF RECOMMENDED ADDITIONAL MONITOR WELLS AND SOIL BORINGS, FUEL

4. Up to 4 additional test pits are recommended for excavation adjacent to newly located facilities. Two of these test pits are recommended for the buried pipes connecting with the former fueling facility.

5. If analyses from the verification sampling (Recommendation 1 above) detect VOA or phenol compounds, then all monitor wells in the array should be sampled and analyzed for these analytes as well as for oil and grease. Any monitor well exhibiting a layer of floating fuel will also be measured for the thickness of that floating fuel. Samples of fuel product from the monitoring wells and up to five seepage points will be tested to determine fuel type.

6.1.5 Other Sites - Recommendations

1. The finding of VOA compounds at the DPDO Storage Area "C" indicates that the process of DPDO storage of liquid wastes is a potentially contaminating operation. In recognition of this, the modern DPDO Storage Area is asphalt-lined and bermed to prevent the escape of spillage to the environment. Prior to occupying Storage Area "C", the DPDO at DIAP had operated two earlier storage areas located in the vicinity of the former fuel loading facility. WESTON recommends that these 2 pads be subjected to a preliminary soil sampling and analysis program in order to determine whether or not residual spillage remains in the soils at those sites. Since the precise locations of the two pads are ill-defined, WESTON recommends drilling and sampling 10 soil exploratory borings in the general area of these 2 pads. Soils samples would be analyzed for VOA compounds using Standard Methods 601 and 602.

2. There is a potential that soil and groundwater contamination occurred in association with the formerly operated fuel loading facility near the existing Fuel Storage Area. In addition to the geophysical survey and test pits recommended above, as an extension to the evaluation of the Fuel Storage Area, WESTON recommends drilling and sampling 6 soil exploratory borings in the area occupied by the former fuel loading facility. Soils sampled would be analyzed for oil and grease as an indicator for fuel oil contamination. Four recommended boring locations are shown on Figure 6-2 and are located adjacent to the buried fuel line leading to the

loading dock. Two additional borings should be located at the loading dock site which is south of the area shown in Figure 6-2.

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AD-A148 318 INSTALLATION RESTORATINN PROGRAM PHASE II STAGE 1 PROBLEM CONFIRMATION STUDY DULUTH INTERNATIONAL AIRPORT DULUTH MINNESOTA(U) WESTON (ROY F) INC WEST CHESTER PA

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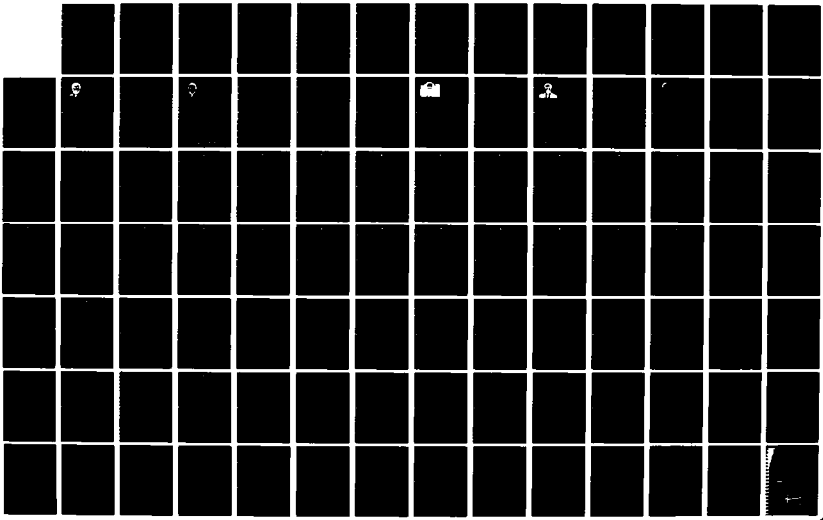

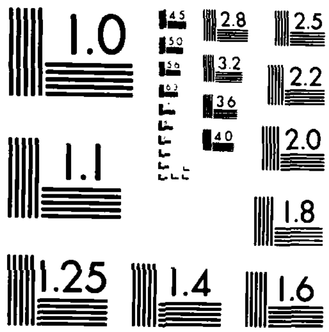
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APPENDIX A

ACRONYMS, DEFINITIONS, NOMENCLATURE AND UNITS OF MEASUREMENT

WESTON

APPENDIX

ANG	Air National Guard
ASTM	American Society for Testing and Materials
Aquifer	zone beneath the earth's surface capable of producing water for a well.
BGS	Below Ground Surface
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
cm/s	centimeters per second
DDD	pesticide compound syn: 1,dichloroethane or TDE. Similar to DDT.
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DPDO	Defense Property Disposal Office
DoD	Department of Defense
DIAP	Duluth International Airport
ground water divide	a line on the water table on each side of which the ground water table slopes away from the line.
ground water surface	the level below which the earth is saturated.
HARM	Hazard Assessment Rating Methodology. A numerical scoring system used to evaluate potentially contaminated sites. The system takes into account site and waste characteristics, pathways of migration and potential receptors of contamination. The HARM system is used to indicate the realtive need for follow-up action.
hydraulic gradient	change in pressure or head in the ground water over a given distance of flow
Intrusive Igneous Rocks	Rock of molten origin that has been injected into existing rock and solidified without reaching the ground surface.
IRP	Installation Restoration Program
ug/l	micrograms per liter (equivalent to parts per billion in water).

umho/cm	micromhos per centimeter (units of Specific Conductance).
ug/g	Micrograms per gram (equivalent to parts per million in water)
ug/kg	Micrograms per kilogram (equivalent to parts per billion in water).
mg/l	milligrams per liter (equivalent to parts per million in water).
mgd	million gallons per day
MSL	Mean Sea Level Datum
N	North
OEHL	Occupational and Environmental Health Laboratory
pH	negative logarithm of the hydrogen ion concentration in water.
PCB	Polychlorenated Biphenyls
P.G.	Registered Professional Geologist
ppb	parts per billion (equivalent to ug/l in water).
ppm	parts per million (equivalent to mg/l in water).
Staff Guage	A stake set in a stream with reference marks for measuring water levels. The elevation of the reference marks is established by a survey.
Syncline	A fold in layers of rock that is concave upward.
TOC	Total Organic Carbon
TOX	Total Organic Halogens, which are organic compounds containing any of the elements of Group VII-b of the Periodic Table (F,Cl,Br,I)
Unconsolidated Sediments	sediments that are uncemented and thus contain interconnected void space (primary porosity) that allow for the storage and transmission of groundwater.
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

VOA	Volatile Organic Compounds
HARM	Hazard Assessment Rating Methodology. A numerical scoring system used to evaluate potentially contaminated sites. The system takes into account site and waste characteristics, pathways of migration and potential receptors of contamination. The HARM system is used to indicate the relative need for follow-up action.

APPENDIX B

SCOPE OF WORK, TASK ORDER 0025

INSTALLATION RESTORATION PROGRAM

Phase IIB Field Evaluation

Duluth International Airport, Minnesota

83 AUG 15

I. Description of Work

The purpose of this task is to determine if environmental contamination has resulted from waste disposal practices at Duluth International Airport MN; to provide estimates of the magnitude and extent of contamination, should contamination be found.

The presurvey report (mailed under separate cover) and Phase I IRP report (mailed under separate cover) incorporated background and description of the sites for this task. To accomplish this investigation the contractor shall take the following actions.

A. Technical Efforts

Four potential contamination sites have been identified:

1. D-1 Goose Missile Site Dump

a. The contractor shall collect a total of eleven core samples (up to three feet in length of bottom sediments) at the following locations:

(1) One core samples shall be taken in the swamp at six locations providing areal coverage.

(2) One core sample shall be taken at an upstream location to provide background data.

(3) One core sample shall be taken at the discharge point of the swampy pond into the drainageway.

(4) One core sample shall be taken at each of three stations spaced at approximately 50 yard intervals downstream along the drainageway.

b. Each core sample shall be shipped under refrigeration to the contractor labortory for analysis. Upon receipt in the laboratory, each core will be frozen and subdivided from the top down into 10 centimeter segments. The upper three segments shall be individually homogenized and analyzed for the following pesticides: Aldrin, dieldrin, chlordane, DDT isomers, endrin, heptachlor, heptachlorepoxide, BHC compounds, lindane and methoxychlor. Utilize method for chlorinated pesticides listed in Standard Method reference. Those cores segments remaining shall be archived frozen for possible future analyses.

c. The contractor shall take one surface water sample from each coring location. Each water sample shall be analyzed for Chlorinated Hydrocarbon pesticides listed in item IA 1b above, Total Organic Carbon (TOC) and Total Organic Halogens. All water samples shall be analyzed on-site by the

contractor for pH, temperature and specific conductance. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references: Standard Methods for The Examination of Water and Wastewater, 15th Ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979). All analyses for pesticides shall strictly comply with the following references: Pesticide Analysis Method: Standard Methods for the Examination of Water and Wastewater, 15th Edition (1980) pp 493-508; U.S. Environmental Protection Agency, (1976) Analysis of Pesticide Residues in Human and Environmental Samples. Environmental Toxicology Division, Health Effects, Research Triangle Park NC. Minimum detection limits for analyses are shown in Attachment 1.

2. Fire Training Sites FT-1 & 2

a. Site FT-1 and FT-2 will be defined as a single waste management unit, due to their adjacent location, similar operation and use of potential contaminents and poorly ascertainable direction of down-gradient flow over the two sites.

b. The contractor shall install seven shallow groundwater monitor wells at depths of 25 feet. Six wells shall be located such that they surround the waste management unit and one well shall be located between site FT-1 and FT-2 at the approximate center of the encirclying array. Each well shall be drilled using hollow-stem auger equipment. Samples will be taken for stratigraphic control purposes every five feet using a split-spoon sampler and standard penetration tests (SPT). Each pilot boring will be logged in accordance with Air Force/USATHAMA Procedures, and boring logs will form a part of Final Report (in Item VI below). During soil boring activities the top of the hole will be monitored for organic vapors and explosive gases using a photoionization detector and explosimeter. Results of this monitoring will be included on the boring logs.

c. Each well will be constructed of two-inch diameter schedule 40 PVC with 10 feet of 0.10-inch slot Johnson UOP Sonic-Welded PVC well screens below the water table. Each well will be gravel-packed with Ottawa gravel to a height of 5 feet above the top of the well-screen, and will be pressure grouted with a grout mixture of 6:1 Portland cement and bentonite powder. Each well will be completed with a security casing of 4-diameter black iron with a cap and hasp. All wells will be developed with either compressed air or a small-capacity submersible pump until they produce clear, sand-free water.

d. Locations and elevations of each well shall be surveyed with respect to a survey benchmark on the base. A complete round of water levels shall be measured not sooner than two weeks following completion of well construction. One water sample shall be taken from each well after three-times the volume of standing water in each well has been pumped from well.

e. Samples shall be obtained using a submersible pump. Each sample shall be analyzed for oils and greases using IR Method and TOC, nitrates and TOX. All water samples shall be analyzed on site by the contractor for pH, temperature and specific conductance. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references:

Standard Methods for The Examination of Water and Wastewater, 15th ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979). Minimum detection limits for analyses are shown in Attachment 1.

3. DPDO Storage Area "C", Site S-2

a. The contractor shall collect 10 five-foot deep soil boring samples on a continuous basis by split spoon methods. Locations for these borings will be selected favoring the side of the site away from the access road, where drum residence times might be expected to be longer than average, as well as the side of the site facing the drainage ditch, where runoff patterns might be expected to concentrate any contaminants which may have been present. In addition the contractor shall take two sediment cores from the drainage ditch; one core adjacent to Site S-2 and one core approximately 50 yards downstream. If sediments in the ditch are to thin to allow coring, then surface grab samples of the available sediments will be substituted.

b. All soil samples shall be shipped under refrigeration to the contractor laboratory and will be frozen upon receipt pending analysis. Core samples from the ditch shall be subdivided as described for cores from Site D-1. Soil samples from the upper two feet of soils shall be individually homogenized in one-foot increments for analysis. The upper two 10-centimeter core segments shall also be selected for analysis. Remaining soil samples will be archived for potential future analysis.

c. The 24 soil and sediment samples shall be analyzed for oils and greases using IR Method and for the U.S.E.P.A. Priority Pollutant List Volatile Organic Compounds using EPA Methods 601 and 602. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references: Standard Methods for The Examination of Water and Wastewater, 15th Ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (`976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979). Minimum detection limits for analyses are shown in Attachment 1.

4. Site SP-1, Tank Farm Area

a. The contractor shall determine from review of the as-built drawings of the POL facilities the potential contaminant migration pathways through trenches containing buried facilities. The locations of these facilities will be compared with the location of the excavation in which fuel oil had been previously encountered (1980 leak approximately 150 feet from Tank No. 3 of Diesel Fuel No. 2).

b. Two sites shall be selected having the highest potential for acting as contaminant migration pathways. At these two sites trenches will be excavated, the excavation shall be monitored for organic vapors and explosive gases using a photo-ionization detector and explosimeter, for presence or absence of fuel oil. Shallow monitor wells shall be installed within the gravel trench-fill immediately adjacent to the buried facility prior to backfilling the excavation. Both wells will be grout-sealed into place to preclude vertical infiltration of overland runoff. The two buried trench wells shall be monitored periodically for organic vapors and explosive gases using

and photo-ionization detector and explosivmeter throughout the project to test for the presence of fuels.

c. The contractor shall take one sample from each of these two wells. Each of the two samples will be analyzed for oils and greases (IR), TOC and lead. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references: Standard Methods for The Examination of Water and Wastewater, 15th ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979). Minimum detection limits for analyses are shown in Attachment 1.

d. The contractor shall accomplish an array of soil explortory borings around the Tank Farm Area. Since POL products float on water, these borings would only be drilled to the water table, an estimated average of 10 feet, 20 borings shall be drilled around the Tank Farm Area. Borings will be split-spoon sampled on a continuous basis, the bore holes and samples will be monitored for organic and explosive vapors using photo-ionization detector and explosivmeter. Observations shall be made as to the presence or absence of fuel odor. Each boring will be backfilled with bentonite-cement grout prior to abandoment. Observations shall be made as to the depth of first water in each boring, and a preliminary map of the water table shall be drawn in the field.

e. Four monitor wells shall be installed in a RCRA-style array, with locations selected by the field geologist and based upon both the preliminary water table map and the results of fuel detection in the exploratory soil borings and buried trench monitor points. The wells shall be documented, constructed and developed in the same manner as the monitor wells at the fire training waste management area (A.2. FT 1&2 above).

f. The wells shall be allowed to equilibrate for not less than two weeks after development, and then static water levels will be measured--if a fuel oil layer is encountered in a well, its thickness shall be measured with a Soiltest Oil-Water Interface Detector. If a fuel oil layer is encountered in any well it shall be sampled separtely for chemical analysis in order to determine which fuel-type it is--samples of the fuels actually in storge shall be used for gas chromatographic standards.

g. One water sample shall be obtained from each of the four monitor wells using a submersible pump. Each sample shall be analyzed for oils and greases (IR), TOC lead. All water samples shall be analyzed on site by the contractor for pH, temperature and specific conductance. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references: Examination of Water and Wastewater, 15th ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979). Minimum detection limits for analyses are shown in Attachment 1.

B. Field data collected for each zone shall be plotted and mapped. The nature of contamination and the magnitude and potential for contaminant flow within each zone to receiving streams and groundwaters shall be determined or estimated. Upon completion of the sampling and analysis, the data shall be tabulated in the next R&D Status report as specified in Item VI below.

C. Well Installation and Cleanup

Well installations shall be cleaned up following the completion of the well. Drill cuttings shall be removed and the general area cleaned.

D. Data Review

Results of sampling and analysis shall be tabulated and incorported in the monthly R&D status report and forwarded to the USAF OEHL for review as soon as they become available as specified in Item VI below.

E. Reporting

1. A draft final report delineating all findings of this field investigations shall be prepared and forwarded to the USAF OEHL as specified in Item VI below for Air Force review and comment. This report shall include a discussion of the regional hydrogeology, well logs of projects wells, data from water level surveys, aquifer test results and conclusions, water quality analysis results, available geohydrologic cross sections, ground water surface and gradient maps, vertical and horizontal flow vectors and laboratory quality assurance information. The report shall follow the USAF OEHL supplied format (mailed under separate cover).

2. Estimates shall be made of the magnitude, extent and direction of movement of contaminants discovered. Potential environmental consequences of discovered contaminations shall be identified and estimated.

3. Specific requirements, if any, for future ground water and surface water monitoring must be identified.

II. Site Location and Dates:

Duluth International Airport Duluth MN
Dates to be established

III. Base Support: None

IV. Government Furnished Property: None

V. Government Points of Contact:

1. Captain Robert W. Bauer
USAF OEHL/CVT
Brooks AFB TX 72835
(572) 536-2158/2159

2. Mr Richard Sobezak
148 TRG
Duluth IAP MN 55811
(218) 727-6886 ext. 214

3. Dr Dee Ann Sanders
USAF OEHL/ECQ
Brooks AFB TX 78235
(512) 536-3305

4. Maj Kenneth Hundley
HQ AFRES/SGPB
Robins AFB GA 31098
(9112) 926-6441

VI. In addition to sequence numbers 1, 5 and 11 listed in Atch 1 to the contract, which are applicable to all orders, the sequence number listed below are applicable to this order. Also shown are data applicable to this order.

Seq Nr	Block 10	Block 11	Block 12	Block 13	Block 14
4	One/R	84JAN16	84JAN30	84APR23	*

*Contractor shall supply the USAF OEHL with 20 copies of draft report and 50 copies plus original camera ready copy of the final report.

ATTACHMENT 1
REQUIRED SAMPLE DETECTION LIMITS

Total Organic Halogen (TOX)	5 micrograms/l
Total Organic Carbon (TOC)	1 milligram/l
Chemical Oxygen Demand (COD)	5 milligrams/l
Oils and Grease IR Method 412.3	0.1 milligram/l (water); 100 microgram/gram(so
Volatile Organic Compounds	*
Pesticides Analyses	**
PCB in soil	1 microgram/gram
Specific Conductance	1 micromho
Total Dissolved Solids	1 milligram/l

Chemicals

Nickel	100milligrams/l
Copper	50 micrograms/l
Lead	20 micrograms/l
Zinc	50 micrograms/l
Chromium	50 micrograms/l
Cadimium	10 micrograms/l
Phenol	1 microgram/l
Cyanide	10 micrograms/l
Polychlorinated Biphenyls (PCB's)	.25 microgram/l
Mercury	1 microgram/l
Hydrazine	50 micrograms/l
Nitrates	0.1 milligram/l
Arsenic	10 micrograms/l
Boron	100 micrograms/l
Chloride	1 milligram/l
Total Iron	100 micrograms/l
Manganese	50 micrograms/l
Sodium	1 milligram/l
Sulfate	1 milligram/l

* Detection limits for volatile aromatics and volatile halocarbons shall be as specified for compounds listed in EPA Methods 601 and 602.

** For waters, analyze samples for chlorinated hydrocarbon and organophosphate type insecticides. Analyze for the following specific pesticides and detection levels:

aldrin	.02 microgram/l
DDT isomer	.02 microgram/l
dieldrin	.02 microgram/l
endrin	.02 microgram/l
heptachlor	.02 microgram/l
heptachlor epoxide	.02 microgram/l
lindane	.01 microgram/l
methoxychlor	.02 microgram/l
diazinon	.02 microgram/l
malathion	.10 microgram/l
parathion	.02 microgram/l
2,4-D	.06 microgram/l
2,4,5-T	.06 microgram/l
2,4,5-T (Silvex)	.02 microgram/l

APPENDIX C

Professional Profiles of Project Personnel

Peter J. Marks

Fields of Competence

Project management; environmental analytical laboratory analysis; hazardous waste, groundwater and soil contamination; source emissions/ambient air sampling; wastewater treatment; biological monitoring methods; and environmental engineering.

Experience Summary

Eighteen years in Environmental Laboratory and Environmental Engineering as Project Scientist, Project Engineer, Process Development Supervisor, and Manager of Environmental Laboratory with WESTON. Experience in analytical laboratory, wastewater surveys, hazardous waste, groundwater and soil contamination, DoD-specific wastes, stream surveys, process development studies, and source emission and ambient air testing. In-depth experience in pulp and paper, steel, organic chemicals, pharmaceutical, glass, petroleum, petrochemical, metal plating, food industries and DoD.

Applied research on a number of advanced wastewater treatment projects funded by Federal EPA.

Credentials

B.S., Biology—Franklin and Marshall College (1963)

M.S., Environmental Engineering and Science—Drexel University (1965)

American Society for Testing and Materials

Water Pollution Control Federation

Water Pollution Control Association of Pennsylvania

Employment History

1965-Present	WESTON
1963-1964	Lancaster County General Hospital Research Laboratory for Analytical Methods Development

Key Projects

USAF/OEHL Brooks AFB. Program Manager for this three-year BOA contract provides technical support in environmental engineering surveys, wastewater characterization programs, geological investigations, hydrogeological studies, landfill leachate monitoring and landfill siting investigations, bioassay studies, wastewater and hazardous waste treatability studies, and laboratory testing and/or field investigations of environmental instrumentation/equipment. Collection, analysis, and reporting of contaminants present in water and wastewater samples in support of Air Force Environmental Health Programs.

United States Army Toxic and Hazardous Materials Agency (USATHAMA), Aberdeen Proving Ground, Maryland. Program Manager for three-year basic ordering agreement contract to provide research and development for technology in support of the DOD Installation Restoration Program. The objective of the Program is to identify and develop treatment methods/technology for containment and/or remedial action. Technology development for remedial action is to include groundwater, soils, sediments, and sludges.

Confidential Client, Ohio. Project Manager of an on-going contract to conduct corporate environmental testing and special projects at client's U.S. and overseas plants. WESTON must be able to assign up to four professionals to a project within a two week notice.

Confidential Client (Inorganic and Organic Chemicals). Product Manager of a current contract to conduct wastewater sampling and analysis of plant effluent for priority pollutants. The project also includes a wastewater treatability study to evaluate a number of process alternatives for removal of priority pollutants from the present effluent.

Confidential Client, Utah. Technical Project Manager for in-depth wastewater survey, in-plant study, treatability study, and concept engineering study in support of the client's objectives to meet 1983 effluent limitations. WESTON had two project engineers, two chemists, five technicians and an operating laboratory in the field. Field effort is six months duration.

Professional Profile

In conjunction with University of Delaware College, WESTON analyzed more than 500 biological and marine sediment samples for eleven constituent trace metals as part of a program to identify and trace the migration of metals from ocean dumping of sludges on the continental shelf off the coast of the State of Delaware, acted as Technical Project Manager.

Project Manager in charge of a wastewater analysis and biological treatability project for industrial client for the identification and degradation of six pesticide-containing wastewaters.

U.S. EPA Environmental Monitoring and Support Laboratory. Multi-year contract to provide reference laboratory analysis on QA/QC samples produced from the EPA Analytical Laboratory QA/QC program.

Publications

"Microbiological Inhibition Testing Procedure," Biological Methods for the Assessment of Water Quality, A.S.T.M. Publication STP 528.

"Heat Treatment of Waste Activated Sludge" (with V.T. Stack).

"Biological Monitoring in Activated Sludge Treatment Process," a joint paper with Stover/Woldman.

Frederick Bopp III, Ph.D., P.G.

Registration

Registered Professional Geologist in the State of Indiana

Fields of Competence

Groundwater resources evaluation; hydrogeologic evaluation of sanitary landfills and other waste disposal sites; detection and abatement of groundwater pollution; digital modeling of groundwater flow and solute transport; statistical analysis of geological and geochemical data; geochemical prospecting; estuarine geology and geochemistry; trace metal and aqueous geochemistry.

Experience Summary

Seven years experience in hydrogeology and geochemistry, involving such activities as: assessment of subsurface water and soil contamination; development of contamination profiles; evaluation of remediation actions for groundwater quality restoration; quantitative chemical analysis of water and soil; ore assay and ore body evaluation; drilling supervisor; hydrogeologic assessment; pollution detection and abatement; estuarine pollution analysis; application of flow and solute transport computer models; computer programming; project management; teaching environmental geology and geochemistry.

Credentials

B.A., Geology—Brown University (1966)

M.S., Geology—University of Delaware (1973)

Ph.D., Geology—University of Delaware (1979)

Sigma Xi, The Scientific Research Society of North America

Geological Society of America, Hydrology Division

National Water Well Association, Technical Division

American Association for the Advancement of Science

Estuarine Research Federation: Atlantic Estuarine Research Society

Employment History

1979-Present	WESTON
1977-1979	U.S. Army Corps of Engineers Waterways Experiment Station
1976-1977	University of South Florida Department of Geology
1970-1976	University of Delaware Department of Geology
1974-1976	Earth Quest Associates President and Principal Partner
1974 (Summer)	WESTON
1966-1970	United States Navy Commissioned Officer

Key Projects

Project manager on seven task orders for environmental assessment services at United States Air Force facilities in nine states.

Task manager for a Superfund site evaluation in Ohio.

Site manager for drum recovery operations in Pennsylvania and New Jersey.

Project manager for site assessments of oil and fuel spills in four states.

Project manager for closure plan development at a hazardous waste landfill in New Jersey.

Definition and abatement of groundwater contamination from chemical manufacturing in Delaware.

Flow and solute transport digital model of a heavily-pumped regional aquifer in southern New Jersey.

Definition and abatement of groundwater contamination from chemical manufacturing in the Denver area.

Hydrogeologic impact assessment of on-land dredge spoil disposal in coastal North Carolina.

Geochemical prospecting and ore body analysis in Arizona.

Professional Profile

Definition and abatement of groundwater contamination from a hazardous waste site in northern New England.

Definition and abatement of groundwater contamination from plating and foundry wastes in eastern Pennsylvania.

Operational test and evaluation of new naval mine ordinances in southern Florida.

Publications

"Metals in Estuarine Sediments: Factor Analysis and Its Environmental Significance". *Science*, 214 (1981): 441-443.

"The Remobilization of Trace Metals from Suspended Sediments Entering the Delaware Estuary". Presented at the 27th Annual Meeting, Southeastern Section, Geological Society of America, Chattanooga, Tennessee, April 1978.

"Trace Metals in Delaware Bay Sediments and Oysters". Presented at the International Conference on Heavy Metals in the Environment, Toronto, Canada, October 1975.

RICHARD C[illegible], P.G.

REGISTRATION

Registered Professional Geologist in the State of Virginia (No. 600)

FIELDS OF COMPETENCE

Hydrologic and geologic investigations of waste disposal sites; engineering properties of soil and rock; laboratory determination of mechanical properties of soils; laboratory investigation of physical properties of sulfite sludges and coal burning wastes; hydrogeological analysis; petroleum contamination of groundwater; optical and x-ray diffraction analysis of geologic materials.

EXPERIENCE SUMMARY

Over six years experience in geotechnical and geological investigations, including hydrologic and geological investigation of landfill sites; quantitative and qualitative groundwater analysis; industrial waste disposal assessment; evaluation of soil mass stability and bearing capacity at proposed sites of building and tank structures; development of remedial actions. Supervision of engineering of laboratory programs for soil and waste material testing; supervision of well installation, well monitoring, and sampling program.

CREDENTIALS

B.A. -- LaSalle College (1969)

M.A., Geology -- Temple University (1976)

Graduate course work in soil mechanics, engineering geology and hydrology -- Drexel University (1979-1981)

AFFILIATIONS

National Water Well Association

U.S. National Group of Engineering Geology

American Geophysical Union

EMPLOYMENT HISTORY

1981-Present	WESTON
1979-1981	Valley Forge Laboratories Devon, Pennsylvania Engineering Geologist Supervisor, Soils and Materials Testing Laboratory
1978-1797	Ambric Engineering Philadelphia Pennsylvania Field Geologist
1976-1977	American Cancer Society Philadelphia Division Philadelphia, Pennsylvania Director of Development and Education
1972-1975	Temple University Department of Geology
1969-1971	City of Philadelphia Department of Licenses and Inspections Housing and Fire Inspector

KEY PROJECTS

Project Geologist for investigation of existing and proposed hazardous-waste disposal sites in Pennsylvania, New Jersey, Ohio, and Maine. Studies included drilling and soil sampling programs; the interpretation of hydrogeologic conditions; and evaluation of the physical stability of earth impoundments.

Project Geologist for U.S. Air Force Installation Restoration Program Phase II studies in New York, New Jersey, Pennsylvania, and Minnesota. Supervised field investigation of waste disposal and spill sites related to base activities.

Principal hydrogeologist for a groundwater and geologic investigation at the Milan Army Ammunition Plant, Tennessee for the U.S. Army Toxic and Hazardous Materials Agency.

Walter M. Leis, P.G.

Registration

Registered Professional Geologist in the States of Georgia (No. 440) and Indiana.

Fields of Competence

Detection and abatement of groundwater contamination; design of artificial recharge wells; deep well disposal; simulation of groundwater systems; hydrogeologic evaluation of hazardous waste sites and landfills; practical applications of geophysical surveys to hydrologic systems, site investigations, and borehole geophysical surveys. Geochemical studies of acid mine drainage and hazardous wastes.

Experience Summary

Sixteen years experience as field hydrogeologist, field supervisor, project director, research director. Six years research involving two consecutive projects: 1) application of geophysical techniques in evaluating groundwater supplies in fractured rock terrain in Delaware and Pennsylvania; 2) project director for an artificial recharge and deep well disposal study. Provided consultation for waste disposal and aquifer quality problems for coastal communities.

Developed geochemical sampling techniques for deep mine sampling. Evaluated synthetic and field hydrologic data for deep formulational analysis in coal field projects.

Earlier research experience involved developing techniques for mapping subsurface regional structures having interstate hydrologic significance, and defining ore bodies by geochemical prospecting.

Credentials

B.S., Biochemistry—Albright College (1966)

M.S., Hydrogeology—University of Delaware (1975)

Cooperative Program Environmental Engineering—University of Pennsylvania

Additional special course work in Geology and Hydrology, Franklin and Marshall College and Pennsylvania State University

Remote Sensing Data Processing Training, Goddard Space Center (1978)

OWRR Research Fellow, 1973

National Water Well Association, Technical Division.

Geological Society of America, Engineering Geological Division.

Society of Economic Paleontologists and Mineralogists

Employment History

1974-Present	WESTON
1973-1974	University of Delaware Water Resources Center
1971-1973	University of Delaware
1967-1971	Pennsylvania Department of Environmental Resources

Key Projects

Definition of groundwater contamination from sanitary landfill leachate and recovery of contaminants to protect heavily used aquifer in Delaware.

Field design studies for artificial recharge and waste disposal wells.

Design and construction of hydrologic isolation systems for various class hazardous wastes.

Design and supervision of chemical and physical rehabilitation of groundwater collection systems in fractured rock and coastal plain areas.

Principal investigator for six projects involving subsurface migration of PCB's in New York, New Jersey, Pennsylvania, and Oklahoma.

Design and construction supervision of hydrocarbon recovery wells in Pennsylvania.

Professional Profile

Geochemical evaluation of coal mine pools in West Virginia.

Geochemistry of subsurface migration of toxic substances.

Principal investigator for eight projects involving migration of volatile chlorinated hydrocarbons in groundwater.

Mineable reserve evaluations for coal, sand and gravel, limestone, clay deposits, mine reclamation, and monitoring.

Design geophysical and remote sensing assessments of hazardous waste disposal areas.

Publications

Leis, W., and R.R. Jordan, 1974, "Geologic Control of Groundwater Movement in a Portion of the Delaware Piedmont", OWRR—DEL 20.

Leis, W., 1976, "Artificial Recharge for Coastal Sussex County, Delaware", University of Delaware Press, Water Resources Center.

Leis, W., D.R. Clark, and A. Thomas, 1976, "Control Program for Leachate Affecting a Multiple Aquifer System, Army Creek Landfill, New Castle County, Delaware", National Conference on Management and Disposal of Residue on Land.

Leis, W., W.F. Beers, J.M. Davidson, and G.D. Knowles, 1978, "Migration of PCB's by Groundwater Transport—A Case Study of Twelve Landfills & Dredge Disposal Sites on the Upper Hudson Valley, New York", Proceedings of the 1st Annual Conference of Applied Research & Practice on Municipal and Industrial Waste.

Leis, W., R.D. Moose, and W.F. Beers, "Critical Area Maps, a Regional Assessment for Karst Topography", Association of Engineering Geologists 1978 Annual Meeting.

Leis, W., and W.F. Beers, "Soil Isotherm Studies to Predict PCB Migration Within Groundwater", (Abstract) ASTM 1979 Annual Meeting, Philadelphia, Pennsylvania.

Thomas, A., and W. Lein, "Physical & Chemical Rehabilitation of Contaminant Recovery Wells", Association of Engineering Geologists 1978 Annual Meeting.

Leis, W., W.F. Beers, and F. Benenati, "Migration of PCB's from Landfills and Dredge Disposal Sites in the Upper Hudson River Valley", New York Academy of Science Symposium on PCB's in the Hudson River.

Leis, W., "Subsurface Reclamation by Counter Pumping Systems: Geologic and Geotechnical Aspects of Land Reclamation", ASCE/AEG 1979 Symposium.

Leis, W., and A. Metry, "Field Characterization of Leachate Quality", Water Pollution Control Federation 1979 Annual Meeting.

Leis, W., and A. Metry, "Multimedia Pathways of Contaminant Migration", Water Pollution Control Federation 1980 Annual Meeting.

Leis, W., and K. Sheedy, "Geophysical Location of Abandoned Waste Disposal Sites", 1980 National Conference on Management of Uncontrolled Hazardous Waste Sites.

Sheedy, K., and W. Leis, 1982, "Hydrogeological Assessment in Karst Environments (chapter)."

James S. Smith, Ph.D.

Fields of Competence

Analytical laboratory management; organic chemistry; mass spectrometry, GC/MS/DS, high and low resolution, chemical ionization and special techniques; gas chromatography including capillary column techniques; high performance liquid chromatography (HPLC); the uses of NMR, IR, UV, visible, inorganic analyses, electrochemical, thermal techniques and surface methodologies (SEM, ESCA, SIMS) to solve industrial problems; the development of quality control measures in analytical protocols; the testing of laboratory safety methodologies; innovation of new analytical techniques and methods to solve industrial, product liability, production and environmental problems.

Experience Summary

Eleven years experience in the supervision of an analytical group involved in solving all types of industrial problems including environmental, product safety, production, research and development. The main emphasis was on the innovative development of analytical methods utilizing instrumental technologies. In-depth experience in the organic chemicals, inorganic chemicals polymer, fiber, tire, solvent, fluorine chemicals, coke and coal tar industries. Numerous scientific presentations. Contributor to three Chemical Manufacturers Association Task Groups: Environmental Monitoring, Groundwater, and Hazardous Waste Response Center

Taught general chemistry, analytical chemistry, organic chemistry, and instrumental analysis for four years at Eastern Michigan University and the University of Illinois

Credentials

B.A. Chemistry—Williams College (1960)

Ph.D., Organic Chemistry—Iowa State University (1964)

Postdoctoral Organic Chemistry—University of Illinois (1966)

Postdoctoral Mass Spectroscopy—Cornell University (1969)

American Chemical Society

American Society for Testing Materials

American Society of Mass Spectroscopists

Employment History

1981-Present	WESTON
1969-1981	Allied Chemical Corporation Corporate Research Center
1966-1968	Eastern Michigan University Assistant Professor of Chemistry
1965-1966	University of Illinois

Key Projects

Directed analytical group for five years of intensive sampling and analysis of a toxic insecticide. Analyses involved soil, air, water, sludge, blood, bile, feces, urine, animal feed, and plant samples to detect the compound at the low parts-per-billion level. The project involved rapid development of new and accurate analytical methods.

Developed an industrumental analytical laboratory consisting of trace environmental analyses, gas chromatography, high performance liquid chromatography, mass spectrometry, surface analyses, X-ray photoelectron spectroscopy and nuclear magnetic resonance spectroscopy including the design and manufacture of instrument modifications, purchasing instruments, and hiring of key personnel.

Isolated, identified, and developed a method of analysis for a colored impurity on a bulk chemical product. Synthesized the colorant for proof of identification and as a standard for future analysis. Proved the mechanism of the development of the color from the packaging materials. Designed new specifications eliminating the problem.

Conducted corporate plant environmental laboratory QA/QC audits including the development of a corporate QA/QC manual.

Professional Profile

Provided an inexpensive and accurate method of analysis of lead for a manufacturing plant effluent. A published methodology in kit form was modified for plant personnel use to measure soluble and total lead in a waste stream without use of excessive manpower or capital. QA/QC procedures were included as well as the use of performance samples.

Supervision of analytical technological advances that lead to either patents and new products in the fields of coal tar chemicals, food packaging and transformer manufacturing.

Publications

Smith, J., A. Weston, and C. Wezwick, "Tire Cord Emission Studies, Conclusion", The International Society of Industrial Yarn Manufacturers, Savannah, Georgia, 3-4 November 1977.

Hanrahan, J., E. McCarthy, D. Richton, J. Smith, and A. Weston, "Identification of an Interfering Compound is the Determination of Dimethylnitrosamine by Gas Chromatography-Mass Spectrometry", 26th Annual Conference on Mass Spectrometry and Allied Topics, St. Louis, Missouri, 28 May to 2 June 1978.

Brozowski, E., D. Jerolamon, D. Richton, D. Smith, J. Smith, and A. Weston, "Industrial Applications of Chemical Ionization with the Ammonium Ion", 26th Annual Conference on Mass Spectrometry and Allied Topics, St. Louis, Missouri, 28 May to 2 June 1978.

Mueller, B.W., L. Palmer, G. Rebyak, and J. Smith, "Analysis of Alpha and Beta Naphthalene Sulfonic Acids by High Performance Liquid Chromatography", North Jersey A.C.A. Chromatography Discussion Group, Nutley, New Jersey, 14 March 1979.

French, C., L. Palmer, and J. Smith, "Analysis of Polymer Oligomers by High Performance Liquid Chromatography", Middle Atlantic Regional A.C.S. Meeting, West Long Branch, New Jersey, 19-23 March 1979.

Burkitt, D. and J. Smith, "A Simple Chromatographic Modification Providing for Rapid Interchange of Capillary and Packed Columns", Middle Atlantic Regional A.C.S. Meeting, West Long Branch, New Jersey, 19-23 March 1979.

Brozowski, E., D. Jerolamon, D. Richton, D. Smith, and J. Smith, "A Convenient Method for the Evaporation of Solvent in the Priority Pollutant Program," Middle Atlantic Regional A.C.S. Meeting, West Long Branch, New Jersey, 19-23 March 1979.

Mady, N., D. Smith, J. Smith, and C. Wezwick, "The Analysis of Kepone in Biological Samples", Proceedings of the 9th Materials Research Symposium, Gaithersburg, Maryland, 10-12 April 1978.

Mueller, B., L. Palmer, and J. Smith, "A High Performance Liquid Chromatographic Method for the Analysis of Bis-phenol-A and Its Impurities", Middle Atlantic Regional A.C.S. Meeting, West Long Branch, New Jersey, 19-23 March 1979.

Gabriel, M., J. Hanrahan, and J. Smith, "A Sensitive Method for the Quantitative Analysis of Pyridine at the Low PPM Level", Middle Atlantic Regional A.C.S. Meeting, West Long Branch, New Jersey, 19-23 March 1979.

Burkitt, D., J. Hanrahan, and J. Smith, "Analysis of Hexachloroacetone and Hexafluoroacetone in Industrial Wastewater", Proceedings of the A.S.T.M. Committee D-19 Symposium, "The Measurement of Organic Pollutants in Water and Wastewater", Denver, Colorado, 19-20 June 1978.

Brozowski, E., D. Burkitt, M. Gabriel, E. McCarthy, J. Hanrahan, and J. Smith, "A Simple, Sensitive Method for the Quantitative Analysis of Carbon Tetrachloride and Chloroform in Water at the Parts Per Billion Level", Proceedings of the 9th Materials Research Symposium, Gaithersburg, Maryland, 10-12 April 1978.

Theodore F. Them, Ph.D.

Fields of Competence

Inorganic and organic chemistry: instrumental analytical techniques; synthesis of organic chemicals; laboratory management; chemical research and education.

Experience Summary

Nine years experience in inorganic and organic chemistry with strong synthetic organic and instrumental analytical background. Experienced researcher and teacher. Background in conceptualizing, founding, effecting, and administering a chemical consulting firm.

Credentials

M.S., Chemistry—University of New Mexico (1975)

Ph.D., Chemistry—University of New Mexico (1977)

American Chemical Society

The Society of Sigma Xi

Southwest Association of Forensic Scientists—Associate Member

Society of Applied Spectroscopy, Rio Grande Section

Employment History

1982-Present	WESTON
1981-1982	Bell Petroleum Services, Inc.
1962-1982	Bell Petroleum Laboratories
1977-1981	AnaChem, Inc Co-Founder, Vice President
1975-1977	University of New Mexico

Practical Experience

Familiarity with use, maintenance, and operation of gas chromatographs with flame ionization, electron capture, thermal conductivity, and photoionization detectors. Experience includes methods development, separation optimization, and data reduction.

Familiarity with use, maintenance, and operation of gas chromatograph/mass spectrometer/data system (GC/MS/DS) in separations and identifications of complex mixtures and molecules. Experience includes methods development, separation enhancement, packed and capillary column techniques, and data reduction.

Familiarity with use and operation of various infrared, nuclear magnetic resonance (NMR), atomic absorption (AA), and liquid chromatographic (LC) instrumentation.

Familiarity with use, maintenance, and operation of Tekmar Models LSC-2 and ALS purge/trap and liquid sample concentrator devices and associated gas chromatographic methods.

Familiarity with use, maintenance, and operation of Fisher Model 490 Coal Analyzer for analysis of moisture, volatiles and ash in coal.

Familiarity with use, maintenance, and operation of Fisher Sulfur Analyzer System for analysis of sulfur in coal and hydrocarbon fuels.

Familiarity with use, maintenance, and operation of Parr Adiabatic Bom Calorimeter and associated Master Controller in calorimetric analysis of coal and coke, foodstuffs, and fuels.

Familiarity with use, maintenance, and operation of Fisher Models Titralyzer II (Fixed End Point) and Tritrimeter II automatic titration systems for analysis of water by pH or millivolt-sensitive methods.

Publications

Hazardous Properties and Environmental Effects of Materials Used in Solar Heating and Cooling (SHAC) Technologies: Interim Handbook, J.Q. Search (ed.), August 1978. Sandia Laboratories report Sand 78-0842 available from National Technical Information Service, Springfield, Virginia.

Professional Profile

APPENDIX D

Boring Logs and Well Completion Summaries

DRILLING LOG

WELL NUMBER: TB-1
OWNER: USAF
LOCATION: TANK FARM
ADDRESS: DULUTH
TOTAL DEPTH: 15
SURFACE ELEVATION:
WATER LEVEL: 4'
DRILLING COMPANY: SOIL EXPLORATION
DRILLING METHOD: AUGER
DATE DRILLED: 10/24/83
DRILLER: L.A.
HELPER: D.S.
LOG BY: RCJ

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1		4/5	0-2' Red-brown med-coarse SAND with a little fine gravel.
				5/6	.85' rec.
		2		4/11	2'-4' Red-brown med-coarse SAND with some fine gravel,
				8/9	tr. silt. .4' rec.
		3		5/7	4'-6' No recovery - gravel layer. (water in auger at 4')
5				3/7	
10		4		6/8	10'-12' Red brown CLAY, some fine-med gravel. 1.5' Rec.
				9/13	
					13' and 14' Auger encountered coarse gravel
15		5		8/75	15'-17' Red brown CLAY, some med-coarse gravel. 7' Rec.
				30/13	
					Installed temporary 2" diameter PVC well point on 10/24/83.
					Removed well point and grouted hole on 10/28/83.

* A.S.T.M. D1586

WESTON

DRILLING LOG

WELL NUMBER: TB2
OWNER: USAF
LOCATION: Duluth AFB Tank Farm
ADDRESS: Duluth
TOTAL DEPTH: 10'
SURFACE ELEVATION:
WATER LEVEL: 4'
DRILLING COMPANY: Twin Cities
DRILLING METHOD: Auger
DATE DRILLED: 10/24/83
DRILLER: L.A.
HELPER: D.S.
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	3/4	0-2' Red Bn f-m SAND, some clay tr gravel
				5/9	damp. 1' Rec.
		2	5/5	3/4	2'-4' Red Br m-c SAND, tr gravel damp
				3/2	2" Rec.
		3	5/5	4/11	4'-5' Grey-black SILT, moist
5				8/9	5'-6' Green CLAY, moist
				5/4	
		4	5/5	10/13	6'-8' Brown Med-Coarse SAND & GRAVEL
				1/3	a little clay - moist .3 ft. Rec.
		5	5/5	6/10	8'-10' Brown SILT & CLAY Rec. .85 ft.
10					Med. SAND, little clay Rec. .42 ft.
					10" - end of boring; water at 7'
					in auger
					Installed temporary 2 inch PVC well
					point on 10/24
					Removed well point and grouted
					hole on 10/28.

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-3
OWNER: USAF
LOCATION: Tank Farm
ADDRESS: Duluth
TOTAL DEPTH: 6
SURFACE ELEVATION:
WATER LEVEL: 4'
DRILLING COMPANY: Twin Cities
DRILLING METHOD: Auger
DATE DRILLED: 10/24
DRILLER: LA
HELPER: DS
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	2/7	0-2' Red Brown m-c SAND, some gravel
				5/5	.7' Rec.
		2		4/9	2-4' Brown f-c SAND, tn. silt damp
				9/9	.82 Rec.
5		3		6/9	4-6' Brown med. SAND, tn gravel, wet
				10/10	Rec .5' water at 4' in auger
					end of boring
					installed temporary PVC well point
10					on 10/24. Removed well point and grouted
					hole on 10/28.
15					
20					

*ASTM D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: TB-4/MW8
OWNER: USAF
LOCATION: TANK FARM
ADDRESS: Duluth
TOTAL DEPTH: 15'
SURFACE ELEVATION:
WATER LEVEL: 4'
DRILLING COMPANY: Soil Exp.
DRILLING METHOD: Auger
DATE DRILLED: 10/24/83
DRILLER: LA
HELPER: DS
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1		4/5	0-2' Red-brown med. SAND, trace clay & gravel
				5/5	.85 Rec.
		2		3/3	2-4' Red brown med coarse sand, trace gravel.
				5/8	.9' Rec.
5		3		4/5	4-6' No recovery, probably cohesionless sand.
				4/4	
		4		1/2	6-8' Red brown med. sand, a little clay, 1.5' Rec.
				1/1	Grey clay, .35' Rec., Wet.
					End of Boring
10					
					10/24/83 - Installed temporary PVC well point.
					10/28/83 - Removed well point and extended boring to 15' to install permanent monitoring well MW8.

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-5

OWNER:

LOCATION: Tank Farm

ADDRESS:

TOTAL DEPTH

SURFACE ELEVATION:

WATER LEVEL:

DRILLING COMPANY:

DRILLING METHOD: Auger

DATE DRILLED: 10/25

DRILLER: LA

HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	4/7	0-2' .1' top soil underlain by Brown CLAY
				4/8	with a little sand 1.0' Rec.
		2	s/s	5/13	2-4' Red brown, Fine Med. SAND, tn clay and
				13/18	gravel Rec .9'
5		3	s/s	4/10	4-6' Brown-red CLAY and SILT w/ trace of
				10/14	gravel Rec. .9'
		4	s/s	2/2	6-8' Red brown CLAY w/ some sand and gravel moist
				5/11	
		5	s/s	4/6	8-10' Brown SAND, some clay. wet.
				5/3	1.2' Rec.
10					

* ASTM D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: TB-6
OWNER: USAF
LOCATION: Tank Farm
ADDRESS: Duluth AFB
TOTAL DEPTH: 12'
SURFACE ELEVATION:
WATER LEVEL: 8'
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/25/83
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	1 4	0-2' Dark brown organic clayey SILT with trace sand,
				3 4	some gravel .5' rec.
		2	s/s	2 1	2-3' Med-dark mott silty CLAY and red sand
				2 1	
		3	s/s	1 1	3-6.5' v dark-med brown organic CLAY and Humus .6 Rec.
5				1 2	
		4	s/s	1 1	6.5-8.5' med green-grey CLAY with trace silt and gravel
				2 5	.8' Rec.
		5	s/s	4 4	8.5-10' med brown CLAY with some gravel water at 8'
				5 3	
10		6	s/s	1 2	10-12' med brown CLAY and SAND grading to CLAY
				2 5	1.75' Rec.
					Set temporary 2" PVC point to 10'.
15					Removed and grouted hole 10/28

* ASTM D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: TB-7 OWNER: USAF

LOCATION: TANK FARM ADDRESS: Duluth

TOTAL DEPTH: 15

SURFACE ELEVATION: WATER LEVEL:

DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25/83

DRILLER: LA HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	1 3	0-3 DK brown organic SILT with organic matter
				1 1	(.4' Rec. 5-1)
		2	s/s	1 1	3-5.5' Dark-med brown CLAY with occ lt. grey laminations.
				1 1	(.5' Rec 5-2)
		3	s/s	1 2	5.5-7 Dark woody PEAT, and humus
5				1 1	(1.2' Rec 5-3)
		4	s/s	.5 .5	7-10' lt green-grey CLAY with trace sand, thin sand layer
				1 4	(1.1 Rec 5-4)
		5	s/s	1 3	(1.25 Rec. 5-5)
				3 3	10-15' Lt. brown CLAY with little silt, moist
10		6	s/s	3 4	(1.8 Rec 5-6)
				5 8	
		7	s/s	4 8	15-15.2' Lt brown CLAY with a bun gravel, some sand.
				13 18	water at 15'
		8	s/s	4 6	
				19+	
					Set temporary 2" PVC point to 15'
					Removed and grouted hole 10/28

* A.S.T.M. D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-8 OWNER: USAF

LOCATION: Tank Farm ADDRESS: Duluth

TOTAL DEPTH: 10'

SURFACE ELEVATION: WATER LEVEL: 7

DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25/8?

DRILLER: LA HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	2 5	0-2 Dark brown organic SILT, a little sand and
				4 4	Rec. .4'
		2	s/s	1 2	2-2.1 Med. gray/green clay with a little silt
				3 3	2.1-4 Dark brown peat with some lt gray clay Rec:.8'
		3	s/s	1 1	4-6 Dark brown organic PEAT with silt, medium green CLAY
5				5 6	with some silt humus, silt, gravel, moist Rec 1.1' med. brown/red c-f SAND with
		4	s/s	3 6	6-8 Med. Gry CLAY with little silt, med-dark silty SAND
				6 4	with some gravel, med. brown SILT & CLAY, tr gravel Rec. 1.4', wet at 7'
		5		3 6	8-10 Stiff red/brown CLAY, moist Rec. 1.4'
				8 11	Augered to 10'
10					
					Set temporary 2" PVC point to 10'
					Removed and grouted hole 10/28

*ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-9/MW-11 OWNER: USAF
LOCATION: Tank Farm ADDRESS: Duluth

TOTAL DEPTH: 10'
SURFACE ELEVATION: WATER LEVEL: 9'
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25/83
DRILLER: LA HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES: MW-11 Replaced TB-9

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	2 4	0-2 Med Red/brn silt and m-c SAND Rec: .4'
				5 4	
		2	s/s	1 13	2-4 Red/brn Sand and CLAY, a little gravel Rec: .4'
				8 8	
		3	s/s	2 2	4-6 Dark brown PEAT, damp Rec: .7'
5				2 3	
		4	s/s	1 2	6-7 Dark brown PEAT with wood chips
		5	s/s	2 4	7-8 Green clay, moist Rec: .7 5'
		6	s/s	2 3	8-10 Lt. brown SILT and CLAY, Med. gray/brown clay
				5 5	with some dark concretions, wet at 9' Rec: 1.1'
10					10/27/83-removed temporary 2" PVC point, augered to 15'
			s/s	5 8	Rec: 1.2' 13-15 Med brown CLAY with some silt, a little gravel
				8 10	end of boring 15'
					10/25 Set temporary 2" PVC well point
					10/27 Removed well point and installed permanent
					monitoring well.
					See construction log for MW-11.

* A.S.T.M. D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB10 OWNER: USAF

LOCATION: Tank Farm ADDRESS: Duluth AFB

TOTAL DEPTH 10'

SURFACE ELEVATION: WATER LEVEL: 3'

DRILLING COMPANY: SOIL EXP. DRILLING METHOD: AUGER DATE DRILLED: 10/25

DRILLER: GL HELPER: M.C.

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	1_1	0-2' sand, organic soil .4' Rec.
				1_2	
		2	s/s	1_1	2-4' Clayey organic soil .7' Rec.
				2_2	rod wet at 3'
		3	s/s	1_2	4-6' clayey PEAT 1' Rec moist
5				3_2	
		4	s/s	1_3	6-7' Grey Green SILT-CLAY, trace sand, soft
				3_3	7-8' m-c SAND, some clay, trace gravel.
		5	s/s	2_2	
				6_8	8-10 Grey CLAY, some fine sand and silt
					10' end of boring
					10/25 Installed temporary PVC well point
					10/28 Removed well point and grouted hole.

* A.S.T.M. D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-11/MW-10　　OWNER: USAF

LOCATION: Tank Farm　　ADDRESS: Duluth

TOTAL DEPTH: 6'

SURFACE ELEVATION: 　　WATER LEVEL: 4'

DRILLING COMPANY: Soil Exploration　　DRILLING METHOD: Auger　　DATE DRILLED: 10/25/83

DRILLER: LA　　HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	3 7 6 6	0-2' Med. brown Sand and GRAVEL, some organic silt Rec:9"
		2	s/s	2 4 5 7	2-4' Med. brown/red Sand and Gravel, Rec: 6"
5		3	s/s	2 3 3 6	4-6' Red/brown SAND with silt, dark brown silt and sand, Rec.: 17"
					10/28/83 Removed temporary 2" PVC point, augered to 13'.
					10/27 Installed temporary 2" PVC well point
10					
					10/28 Removed well point and augered to 13 feet to install permanent well MW-10. (See well construction log end of boring 13'.

* A.S.T.M. D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: TB-12/MW-9 OWNER: USAF
LOCATION: Tank Farm ADDRESS: Duluth AFB
TOTAL DEPTH: 10'
SURFACE ELEVATION: WATER LEVEL: 7'
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25/83
DRILLER: LA HELPER: DS
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	5 10	0-2' Med brown-red med.-coarse SAND Rec: .5'
				7 5	
		2	s/s	4 4	2-4' Med brown red med SAND w/ some clay, Rec: .85'
				3 3	
		3	s/s	4 4	4-6' No recovery, rock in samples
5				2 2	
		4	s/s	4 4	6-8' Med Red/brown CLAY with sand Rec: .15'
				3 4	
		5	s/s	2 4	8-10' Med brown sticky CLAY, tr gravel and sand, moist
		6	s/s	4 8	Rec: 1.2'
10					10/28/83 - Removed temporary 2" PVC point, augered to 13'
					11-13 Dark brown SILT and CLAY
					Set temporary 2" PVC point at 10'
					Installed permanent well MW-9 on 10/28.

* A.S.T.M. D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-13
OWNER: USAF
LOCATION: Tank Farm
ADDRESS: Duluth AFB
TOTAL DEPTH: 6'
SURFACE ELEVATION:
WATER LEVEL: 4'
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/25/83
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	3 4	0-2' Med. brown SAND and GRAVEL Rec .7'
				7 4	
		2	s/s	2 3	2-4' Med. brown/red SAND with some silt, Rec: .7'
				3 5	wet at 4'
		3	s/s	1 1	4-6' Med. brown/red SAND, some gravel, black concretions
5				2 8	peat from 5.5-6.0' Rec: 1.25'
10					
					Set temporary 2" PVC point at 6'
					Removed and grouted 10/28

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-14 OWNER: USAF
LOCATION: Tank Farm ADDRESS: Duluth AFB
TOTAL DEPTH: 8'
SURFACE ELEVATION: WATER LEVEL: 6'
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25
DRILLER: LA HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	S/S	4 2	0-2 Dark brown SILT, some sand, petroleum odor Rec: .6'
				2 5	
		2	S/S	2 2	2-4 Dark brown SILT, dark SAND with wilt, organic PEAT and
				1 3	HUMUS Rec. .7'
		3	S/S	1 2	4-6 Dark brown PEAT, strong petroleum odor, WOOD, wet
5		4	S/S	2 3	Rec: 1.0'
		5	S/S	3 3	6-7 PEAT and WOOD, visible fuel and strong odor, gravel
		6	S/S	3 3	7-8 Lt. gray/green CLAY, fuel oil Rec: 1.2'
10					
					Set temporary 2" PVC point to 10'
					Removed and grouted hole 10/28

*ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-15 | OWNER: USAF

LOCATION: Tank Farm | ADDRESS: Duluth AFB

TOTAL DEPTH: 6'

SURFACE ELEVATION: | WATER LEVEL: 5'

DRILLING COMPANY: Soil Exploration | DRILLING METHOD: Auger | DATE DRILLED: 10/28/83

DRILLER: LA | HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
		1	s/s	6 6	0-2 Med brown/red SILT and SAND with gravel, med. petro-
				6 7	leum odor Rec: .5'
		2	s/s	3 4	2-2.5 Med. brown SAND with silt, strong petroleum odor
		3		6 8	2.5-4 Med. brown CLAY with silt, strong petroleum odor, Rec: 1.2'
		4		2 4	4-5 Med. brown CLAY with some fine sand, liquid petroleum
		5		7 8	5-6 Dark brown SAND with silt, liquid petroleum and
					water Rec: 1.2' Wet at 5.5'.
					Set temporary 2" PVC point at 6'.
					Removed and grouted on 10/28

* ASTM D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: TB 16 OWNER: USAF
LOCATION: Tank Farm ADDRESS: Duluth AFB
TOTAL DEPTH: 8'
SURFACE ELEVATION: WATER LEVEL: 2'
DRILLING COMPANY: Soil Exp DRILLING METHOD: Auger DATE DRILLED: 10/25
DRILLER: GL HELPER: MC
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	1 1	0-2' sandy PEAT
				2 2	
		2	s/s	1 1	2-4' PEAT, gas odor .5' Rec.
				1 2	
		3A	s/s	1 2	4-5' PEAT .5' Rec.
5		3B		2 4	5-6' Green CLAY, firm, wet. 1.0' Rec.
		4	s/s	2 3	6-8' Brown CLAY with some sand. 1.2' Rec.
				4 7	8' end of boring
10					

* A.S.T.M. D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: TB-17 OWNER: USAF
LOCATION: Tank Farm ADDRESS: Duluth AFB
TOTAL DEPTH 8'
SURFACE ELEVATION: WATER LEVEL: 7'
DRILLING COMPANY: Soil Exp. DRILLING METHOD: Auger DATE DRILLED: 10/25
DRILLER: GL HELPER: MC
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	2 2	0-2' Brown coarse SAND, a little gravel
				5 5	.5 Rec. petroleum odor
		2A	s/s	1 2	2-3' Coarse SAND and GRAVEL .2' Rec.
		2B		2 3	3-4' PEAT .8' Rec.
5		3A	s/s	2 2	4-5' Clayey PEAT 1.0 Rec.
		3B		2 5	5-6' Green CLAY, firm, moist .4' Rec.
		4A	s/s	5 4	6-7' Brown SILT and CLAY, trace gravel, firm,moist
		4B		4 4	7-8' Brown SILT and SAND, trace gravel, wet.
					8' end of boring
10					
15					

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB 18
OWNER: USAF
LOCATION: Tank Farm
ADDRESS: Duluth AFB
TOTAL DEPTH: 8'
SURFACE ELEVATION:
WATER LEVEL: 4'
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/25
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	6 11	0-1 Med. brown SILT with some clay, mod petroleum odor
		2	s/s	18 14	0-2 Med brown SILT and SAND, med petroleum odor Rec: 1.2'
		3	s/s	3 4	2-3 Med brown vf SAND and SILT, strong petroleum odor
		4	s/s	3 3	3-4 Med brown SILT and CLAY, some gravel, strong petroleum odor Rec. 1.2'
5		5	s/s	1 2	4-5 Med brown-lt green/gray CLAY, some peat, strong petroleum odor
		6	s/s	3 6	5-6 Dark brown organic PEAT, strong petroleum odor, Rec: 1.2', wet at 6'
		7	s/s	3 9	6-7 Med brown c SAND with some silt, strong petroleum odor.
				12 9	augered to 8'
10					
					Set temporary 2" PVC point to 8'
					Removed and grouted hole

* A.S.T.M. D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-19 OWNER: USAF
LOCATION: Tank Farm ADDRESS: Duluth AFB
TOTAL DEPTH: 8'
SURFACE ELEVATION: WATER LEVEL: 7'
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25
DRILLER: LA HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	4 8	0-2' Med brown CLAY and GRAVEL with some sand, med-dark brown
				5 4	SILT and GRAVEL with some sand, mod petroleum odor, Rec. .75'
		2	s/s	1 1	2-4' Dark brown organic PEAT with some silt, mod petro- ~~leum~~ od~~or~~
		3		1 2	dark brown organic PEAT Rec: .7'
5		4	s/s	1 1	4-6' Dark brown PEAT, some petroleum odors, dark brown
		5		3 5	mott clay to gray clay Rec: 1.4'
		6	s/s	2 8	6-8' Med gray-green-brown CLAY, very strong petroleum odor
		7		11 10	GRAVEL with silt, sand liquid petroleum, Rec. 1.0'
					8' end of boring
10					
					Set temporary 2" PVC point to 8'
					Removed and grouted hole 10/28

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-20
LOCATION: Tank Farm
OWNER: USAF
ADDRESS: Duluth AFB
TOTAL DEPTH: 10'
SURFACE ELEVATION:
WATER LEVEL: 8'
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/25
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	5 7	0-2' Red/brown SILT with clay and gravel, GRAVEL and brown
					silt, medium gray-green CLAY, strong petroleum odor, Rec: 1.0'
		2	s/s	6 3	2-4' Med brown/gray SILT with fine sand, little gray clay and gravel
				4 4	strong petroleum odor Rec: 1.0'
		3	s/s	2 2	4-6' Med brown/gray SILT and f. SAND, strong petroleum odors
5		4		3 3	dark brown PEAT, med brown/gray SILT and f. SAND, gravel Rec: 1.25'
		5	s/s	3 1	6-8' WOOD, moist, med brown/gray SILT and CLAY, strong
		6		6 7	petroleum odors, Rec: 1.0'
		7	s/s	2 3	8-10' Med brown SAND with silt, med brown stiff CLAY with
		8		4 6	some silt. Liquid fuel, Rec: 1.2', wet at 8'.
10					10' end of boring
					Set temporary 2" PVC Point to 10'
					Removed and grouted 10/28

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: TB-1 OWNER: USAF
LOCATION: TANK FARM ADDRESS: DULUTH
TOTAL DEPTH 15
SURFACE ELEVATION: WATER LEVEL: 4'
DRILLING COMPANY: SOIL EXPLORATION DRILLING METHOD: AUGER DATE DRILLED: 10/24/83
DRILLER: L.A. HELPER: D.S.
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1		4/5	0-2' Red-brown med-coarse SAND with a little fine gravel.
				5/6	.85' rec.
		2		4/11	2'-4' Red-brown med-coarse SAND with some fine gravel,
				8/9	tr. silt. .4' rec.
		3		5/7	4'-6' No recovery - gravel layer. (water in auger at 4')
5				3/7	
10					
		4		6/8	10'-12' Red brown CLAY, some fine-med gravel. 1.5' Rec.
				9/13	
					13' and 14' Auger encountered coarse gravel
15		5		8/75	15'-17' Red brown CLAY, some med-coarse gravel. 7' Rec.
				30/13	
					Installed temporary 2" diameter PVC well point on 10/24/83.
					Removed well point and grouted hole on 10/28/83.

* A.S.T.M. D1586

SHEET 1 OF 1

WESTON

DRILLING LOG

WELL NUMBER: C-1
OWNER: USAF
LOCATION: DCMD
ADDRESS: Duluth AFM
TOTAL DEPTH 5'
SURFACE ELEVATION:
WATER LEVEL: Dry
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/26/83
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0–1		1	grab		0-1' Brown SAND and GRAVEL, oil staining
1–2		2	s/s	4 6	1-3' ditto
2–3		3		1 2	
3–4		4	s/s	2 4	3'-5' ditto
4–5		5		4 8	

H-NU photo-ionizer readings in borehole

(5:32 pm) Background - 8.0 ppm

Depth 0' - 20.0 (30.0 peak)

1' - 30.0 (50.0 peak)

3-5' - 10.0

Back filled hole 10/28/83

*ASTM D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: C-2
LOCATION: DCMD
SURFACE ELEVATION:
DRILLING COMPANY: Soil Exploration
DRILLER: LA
LOG BY: RCB

OWNER: USAF
ADDRESS: Duluth AFB
TOTAL DEPTH 5'
WATER LEVEL: Dry
DRILLING METHOD: Auger
HELPER: DS
DATE DRILLED: 10/26/83

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	grab		0-1' Brown SAND and GRAVEL, with some staining
1		2	s/s	1 2	1-3' Brown silty clay, moist, with some organic matter,
2		3		4 3	Rec: 1.2'
3		4	s/s	1 2	3-4' CLAY with peat; moist
4		5		2 3	4-5' CLAY with some silt, moist Rec: 1.3
5					

H-NU photo-ionizer readings in borehole

(5:34 PM) Background - 8.0

Depth - 0' - 9.0
1' - 9.0
3-5' - 0

Backfilled hole 10/28/83.

* A S T M D1586

SHEET ____ OF ____

WESTON
DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: C-3 OWNER: USAF
LOCATION: DCMD ADDRESS: Duluth AFB
TOTAL DEPTH 5'
SURFACE ELEVATION: WATER LEVEL: Dry
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/26/83
DRILLER: LA HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0					
1		1	grab		0-2' Brown SAND and GRAVEL
2		2	s/s	2 2	
3		3		3 5	2-3' Brown CLAY with some silt, moist Rec: .4'
4		4	s/s	2 3	3-5' Brown CLAY, wet Rec 1.3'
5		5		3 3	

H-NU photo-ionizer readings in bore hole

(5:36 pm)	Background	- 8.0 ppm
	Depth -0'	- 9.0
	1'	- 9.0
	3-5'	- 5.0

* A S T M D1586

SHEET ____ OF ____

WESTON

DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: C-4 OWNER: USAF

LOCATION: DCMD ADDRESS: Duluth AFB

TOTAL DEPTH: 5'

SURFACE ELEVATION: WATER LEVEL: Dry

DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/26/83

DRILLER: LA HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	grab		0-1' Brown SAND and GRAVEL with some silt
1		2	S/S	2 4	1-3' ditto Rec. 1.4'
2		3		6 17	
3		4	S/S	2 2	3-5' Brown/green CLAY and SILT, Rec: .85'
4		5		3 3	
5					
					H-NU photo-ionizer readings in borehole
					(5:38 pm) Background - 8.0 ppm
					Depth 0' - 13.0
					1' - 10.0
					3-5' - 5
					Backfilled hole 10/28/83.

* ASTM D1586

SHEET ____ OF ____

WESTON

DRILLING LOG

WELL NUMBER: C-5
OWNER: USAF
LOCATION: DCMD
ADDRESS: Duluth AFB
TOTAL DEPTH: 5'
SURFACE ELEVATION:
WATER LEVEL: Dry
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/26/83
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0–1		1	grab		0-1' Brown Sand and GRAVEL
1–2		2	S/S	2 4	1-3' Brown Sand and GRAVEL with some silt, Rec.4'
2–3		3		6 17	
3–4		4	S/S	2 2	3-5' Brown/green CLAY and SILT, Rec: .85'
4–5		5		3 3	

HNU photo-ionizer readings in borehole:

(3:04pm) Background - 4.2 ppm

Depth 0' - 5.0

1' - 2.0

3-5' - 30.0 (max)

Backfilled hole 10/28/83

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: C-6 OWNER: USAF
LOCATION: DCMD ADDRESS: Duluth AFB
TOTAL DEPTH: 5'
SURFACE ELEVATION: WATER LEVEL: Dry
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/26/83
DRILLER: LA HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	grab		0-1' Brown SAND and GRAVEL, solvent odor.
1		2	s/s	2 2	1-2' Brown CLAY with some sand and organic matter, (solvent odor).
2		3		3 2	2-3' Brown CLAY with organic matter, Rec: .7
3		4	s/s	1 1	3-5' Brown CLAY with sand and silt; (organic matter solvent odor).
4		5		2 4	Rec: .85'
5					
					HNU photo-ionizer readings in borehole
					(2:15) Hole - 1' depth 70.0 ppm
					(5:42) Background 8.0
					depth 0' 25.0
					1' 50.0 (70. peak)
					3-5' 40.0
					Backfilled hole 10/28/83

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: C-7   OWNER: USAF
LOCATION: DCMD   ADDRESS: Duluth AFB
TOTAL DEPTH: 5'
SURFACE ELEVATION: WATER LEVEL: Dry
DRILLING COMPANY: Soil Exploration   DRILLING METHOD: Auger   DATE DRILLED: 10/26/83
DRILLER: LA   HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	grab		0-1' Brown SAND and GRAVEL with some silt.
1		2	s/s	2 3	1-2' Brown SAND with some silt and organic matter
2		3		2 2	2-3' Brown CLAY Rec: .7'
3		4	s/s	1 1	3-5' Brown CLAY with some sand and organic matter, moist Rec: .85'
4		5		5 6	
5					
					HNU photo-ionizer readings in borehole:
					(2:00pm) Background - 4.0 ppm
					Depth 0 depth - 5.0
					1-2 depth - 14.0
					3-5 - 0
					Backfilled hole 10/28/83

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: C-8 OWNER: USAF
LOCATION: DCMD ADDRESS: Duluth AFB
TOTAL DEPTH: 5'
SURFACE ELEVATION: WATER LEVEL: Dry
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/26/83
DRILLER: LA HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	grab		0-2' Brown SAND and GRAVEL with some silt
1		2	s/s	3 4	
2		3		4 7	2-3' Brown CLAY Rec. .7'
3		4	s/s	2 3	3-5' Brown CLAY with a little sand, a little organic matter, Rec: 1.2'
4		5		4 6	
5					

HNU photo-ionizer readings in borehole

(1:35pm) Background		4.0 ppm
	Depth 0'	4-4.2
	1-2'	8-9 (peak:12)
	3-5'	0

Backfilled hole 10/28/83

* ASTM D1586

SHEET ___ OF ___

WESTON DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: C-9 OWNER: USAF

LOCATION: DCMD ADDRESS: Duluth AFB

TOTAL DEPTH 5'

SURFACE ELEVATION: WATER LEVEL: Dry

DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/26/83

DRILLER: LA HELPER: DS

LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0					
1		1			0-2' Brown SAND and GRAVEL with some silt
2		2	S/S	2 3	2-4' ditto Rec .7'
3		3		4 4	
4		4	S/S	2 6	3-4' Brown CLAY with some sand, a little silt, a little organic matter
5		5		9 8	4-5' Brown CLAY with some sand and silt Rec: .7'
					HNU photo-ionizer readings:
					(11:55 am) Background 6.0 ppm
					Depth 1' 9.0 (max)
					3-5 0
					Backfilled hole 10/28/83

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: C-10
LOCATION: DCMD

OWNER: USAF
ADDRESS: Duluth AFB

TOTAL DEPTH 5'
SURFACE ELEVATION:
WATER LEVEL: Dry

DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/26/83
DRILLER: LA
HELPER: DS
LOG BY: RCB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	S/S	7 10	0-2' Brown Sand and Gravel with some silt Rec. 7"
1		2		4 9	
2		3	S/S	3 3	2-4' Brown SAND and CLAY, with some gravel, brown sand
3		4		2 4	and clay, Rec: 7"
4		5	S/S	1 2	4-5' Brown sandy Clay Rec: 1.0'
5					

HNU photo-ionizer readings in borehole

(10:40 am)	Background	6.5 ppm
	depth 0'	6.5
	1'	9.8
	3-5	0

Backfilled hole 10/28/83.

* ASTM D1586

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: MW-1
OWNER: USAF
LOCATION: Fire Training Area 1
ADDRESS: Duluth Minn.
TOTAL DEPTH: 26.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Twin Cities
DRILLING METHOD: Auger
DATE DRILLED: 10/26
DRILLER: G.L.
HELPER: M.C.
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	5/10	0-2' Fill, f-c SAND some clay and gravel
				25/12	.3' Rec.
			A		3-4.5' Organic soil, black
		2	s/s	9/15	5-7' lt. brown f-SAND and CLAY, a little sub-
5					angular gravel. damp. Probably fill .5' Rec.
					(lower bit resistance below 7 ft.)
					0-10' is fill.
10		3		3/4	10-12' Top soil and organic subsoil. Brown SILT
				4/5	with roots. damp. Rec .8ft.
15		4		6/10	15-16' Brown f-c SAND, some clay, a little gravel
				11/27	wet cohesive
					16-17' Red brown SAND and CLAY, trace of gravel
					wet, cohesive Rec. 2.0'
20					

* ASTM D1586

WESTON

DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: MW1 (cont.)

OWNER:

LOCATION:

ADDRESS:

TOTAL DEPTH

SURFACE ELEVATION:

WATER LEVEL:

DRILLING COMPANY:

DRILLING METHOD:

DATE DRILLED:

DRILLER:

HELPER:

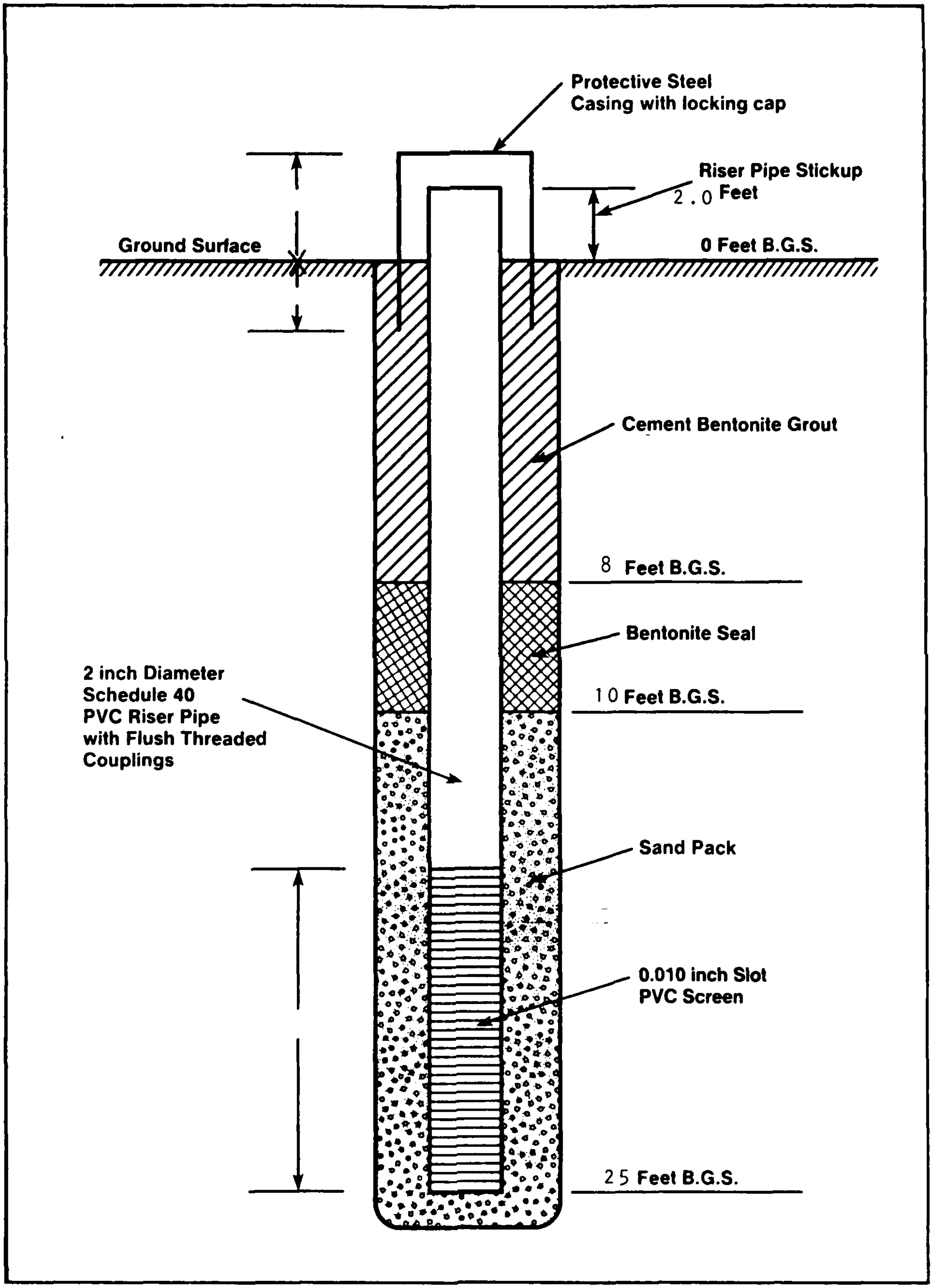
LOG BY:

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
20		5	s/s	43 51	20-21.5 Brown Med. SAND, a little clay and
					gravel. wet Rec. 1.5 ft
					(boulder at 22')
					25-26.5 Brown m-c SAND, some clay, a little
25					gravel
					26.5' End of boring
					Explosimeter monitor during drilling:
					No response. No response in well or annular
					space after screen is placed.
					WELL CONSTRUCTION
					15'-25' .010" slot, 10 ft. PVC screen, 2 inch diam.
					10'-25' gravel pack
					7'-10' bentonite
					0-7' grout seal
					developed by bailing

* ASTM D1586



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-1

WESTON

DRILLING LOG

WELL NUMBER: MW-2
OWNER: USAF
LOCATION: Fire Training Area 2
ADDRESS: Duluth Minn.
TOTAL DEPTH: 26.8
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Twin Cities
DRILLING METHOD: Auger
DATE DRILLED: 10/26/83
DRILLER: G.L.
HELPER: M.C.
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	3/7	0-2' Brown SAND and SILT, a little
				10/ 11	gravel, damp. .5' Rec.
5		2	s/s	6/4	4-6' Brown CLAY, some sand, trace gravel
				4/3	damp. 1.0' Rec.
					(0-10' is backfill)
10		3	s/s	3/3	10-12' .2' organic soil (top soil horizon)
				7/12	1.1' Brown CLAY and SAND, a little
					gravel, wet cohesive.
15		4	s/s	7/12	15-16.5' no recovery - driving rock fragment
				1	
20					

* A S T M D1586

WESTON

DRILLING LOG

WELL NUMBER: MW 2 (cont.) OWNER:

LOCATION: ADDRESS: Duluth

TOTAL DEPTH:

SURFACE ELEVATION: WATER LEVEL:

DRILLING COMPANY: DRILLING METHOD: DATE DRILLED:

DRILLER: HELPER:

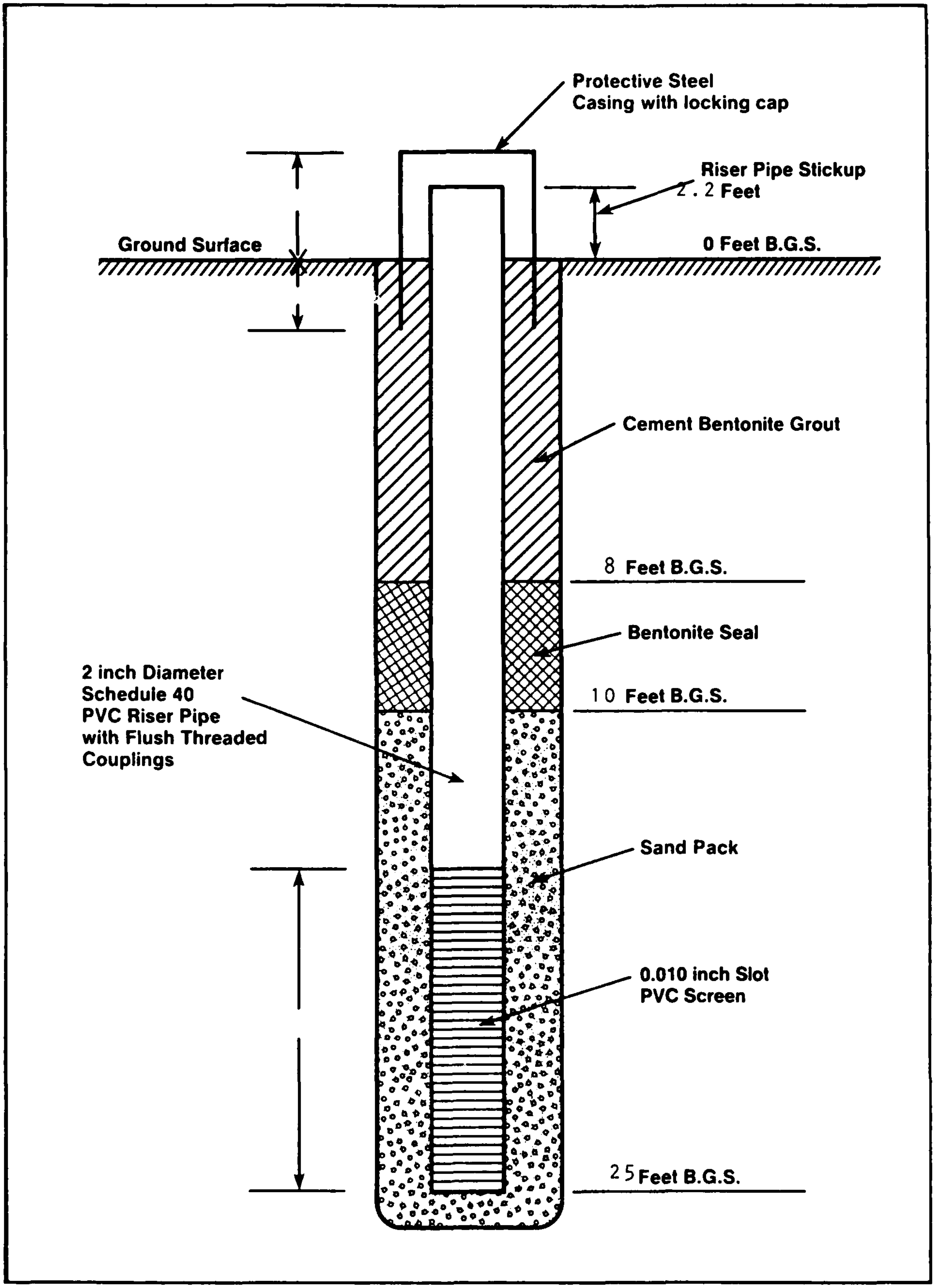
LOG BY:

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
20				6/8	20-22' Red brown CLAY, some silt and sand
				18/ 36	with a little subangular gravel
					wet, cohesive 1.5' Rec.
25				6/11	25-26.8' .5' coarse SAND and CLAY, tn gravel
				10/ 30/ .3	.5' Brown CLAY, trace sand and gravel
					Refusal to spoon at 26.8 feet, ~~Well construction~~ end of boring.
					2" diam. PVC riser pipe 0-15'
30					2" diam., 010" slot PVC screen 15'-25'
					gravel pack 10'-25'
					bentonite pellets 8'-10'
					grout 0'-8'
					Explosimeter reading 20 percent
					in annular space. Not detectable
					at working level

* ASTM D1586



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-2

WESTON

DRILLING LOG

WELL NUMBER: MW -3 (A)
OWNER: USAF
LOCATION: FIRE TRAINING Area 2
ADDRESS: DULUTH
TOTAL DEPTH: 11
SURFACE ELEVATION:
WATER LEVEL: dry
DRILLING COMPANY: Twin Cities
DRILLING METHOD: Auger
DATE DRILLED: 10/26/83
DRILLER: GL
HELPER: ML
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	2 5	0'-2' Brown fine SAND, some Gravel, a little silt & clay damp. 1.4' Rec.
5		2	s/s	5 4 14 14	5'-7' SAND and CLAY FILL, misc. rubble
10		3	s/s	25+	10-10.8 Brown CLAY, some f-m sand. Refusal to split spoon at 10.8'. 04' Rec.
					11' - Refused to auger. End of Boring
					Explosimeter: 50 percent in open hole.
					Boring abandoned and backfilled with grout. MW-3 moved 5 feet to location B. (See log for MW-3B

* ASTM D1586

WESTON

DRILLING LOG

WELL NUMBER: MW3(B) OWNER: USAF

LOCATION: Fire Training Area 2 ADDRESS: Duluth

TOTAL DEPTH: 14'

SURFACE ELEVATION: WATER LEVEL: 10'

DRILLING COMPANY: Twin Cities DRILLING METHOD: DATE DRILLED: 10/26/83

DRILLER: GL HELPER: MC

LOG BY: RCJ

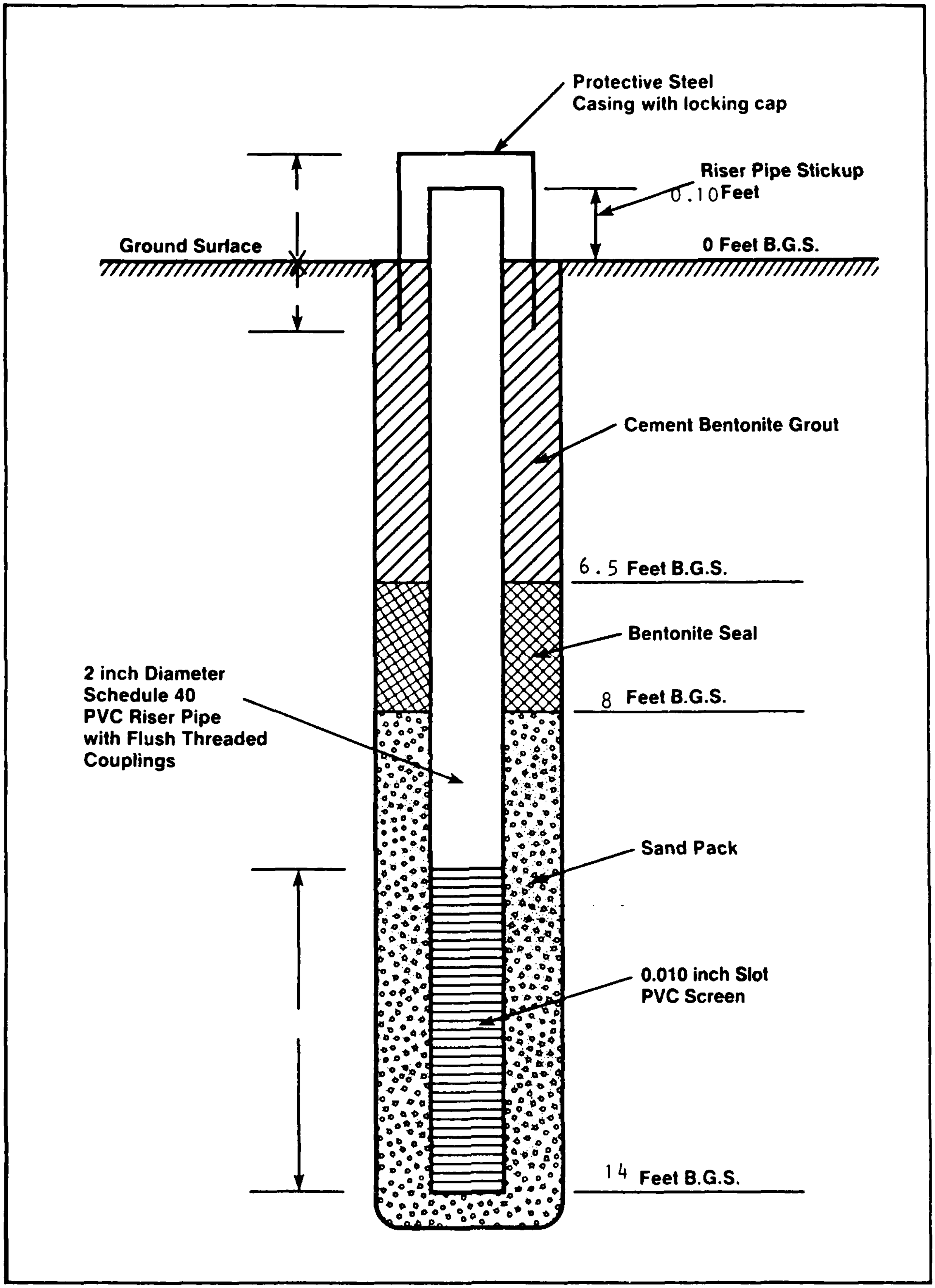
SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0					0-10' no sampling - see boring description
					for 3A
5					Explosimeter reading - No response
					while drilling. During well screen
					installation initial reading in borehole
					was 50 percent - dropped to 18 percent
					in 5 minutes. No surface response
					10-11.5' Brown med-coarse SAND,
10		4	s/s	8 16	some clay and a little gravel
				13	moist-wet. 1.3' Rec.
					(water bearing zone 10-14')
					hard drilling at 13"
					refusal to auger at 14'
15					Well construction:
					9-14' 2" diam. PVC .010" slot screen
					0-9' 2" diam. PVC riser pipe
					8-14' gravel backfill
20					6.5-8' bentonite pellets
					0-6.5' grout

* ASTM D1586

SHEET ____ OF ____



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-3

WESTON

DRILLING LOG

WELL NUMBER: MW4

OWNER: USAF

LOCATION: Fire Training Area 1

ADDRESS: Duluth

TOTAL DEPTH: 20'

SURFACE ELEVATION:

WATER LEVEL:

DRILLING COMPANY: Twin Cities

DRILLING METHOD: Auger

DATE DRILLED: 10/26/83

DRILLER: GL

HELPER: MC

LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	1/5 5/4	0-2' Brown SAND, some clay, a little angular gravel. Some organic soil 1.2' Rec.
5		2	s/s	8 13 19	5-6.5' Brown SILT, some fine sand, trace of gravel, moist. 1.3' Rec.
10		3	s/s	11 28 18	10-11.5' Red-brown CLAY, some med. sand and trace of gravel. stiff, wet
					10'-13' Water bearing zone
					13' hard drilling
15		4	s/s	120 108 63	15-16.5' Bn Med-coarse SAND, some gravel. a little clay damp, very dense 1.0' Rec.
20					

* A.S.T.M. D1586

WESTON
DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: MW4 (cont.) OWNER: USAF
LOCATION: ADDRESS: Duluth
TOTAL DEPTH:
SURFACE ELEVATION: WATER LEVEL:
DRILLING COMPANY: DRILLING METHOD: DATE DRILLED:
DRILLER: HELPER:
LOG BY:

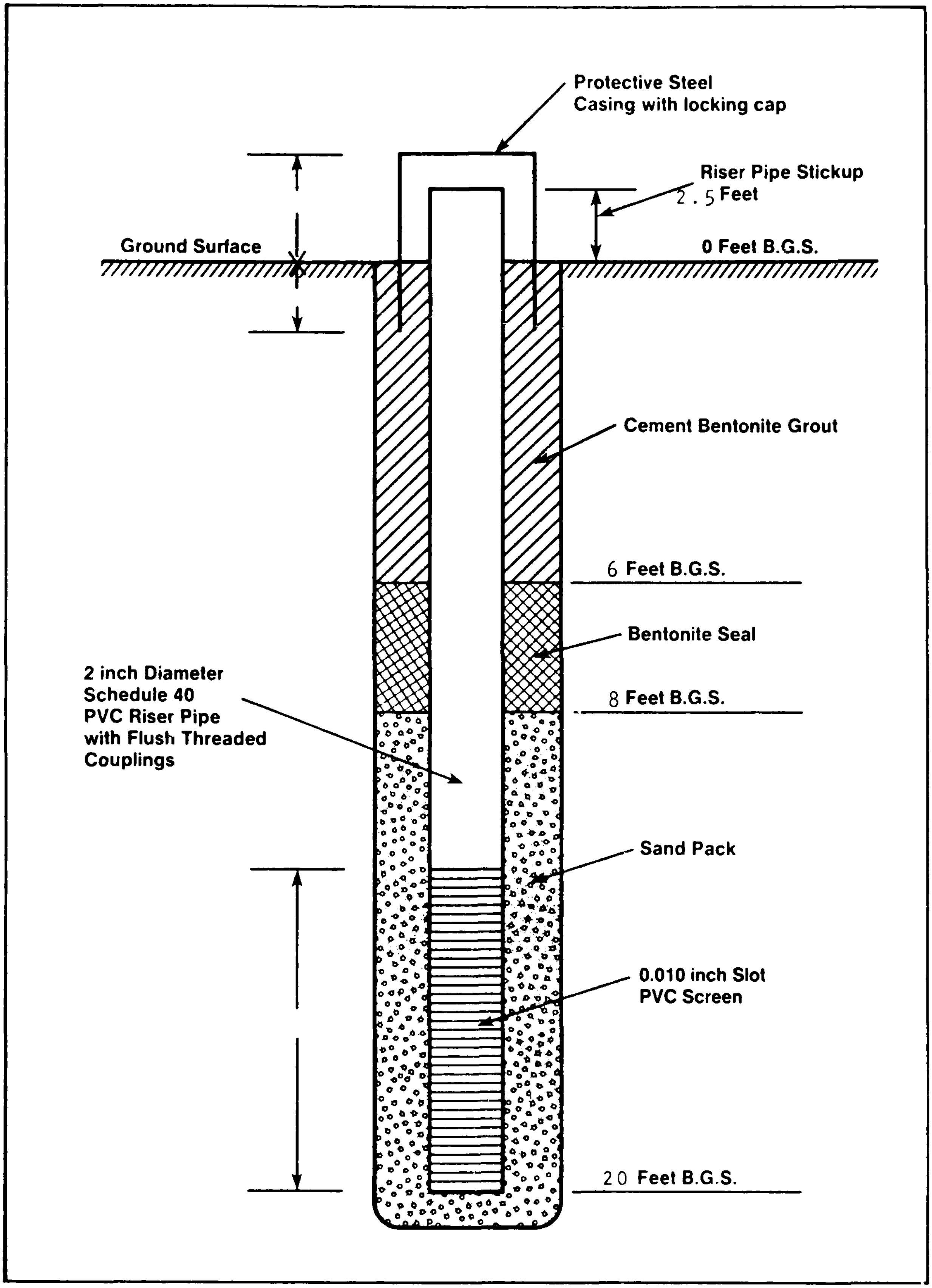
SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
20					20' Refusal to spoon and auger
					Water is perched at 13'
					Well Construction
					10-20' 2" diam PVC screen .010 slot
					0-10' 2" diam. PVC riser pipe
					8-20' sand pack
					6-8' bentonite pellets
					0-8' cement/bentonite grout
					No response on explosimeter.

* ASTM D1586

SHEET 2 OF 2



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-4

WESTON

DRILLING LOG

WELL NUMBER: MW-5 OWNER: USAF

LOCATION: Fire Training Area 1 ADDRESS: Duluth

TOTAL DEPTH: 20

SURFACE ELEVATION: WATER LEVEL: 10'

DRILLING COMPANY: Soil Exp. DRILLING METHOD: Auger DATE DRILLED: 10/27

DRILLER: GL HELPER: MC

LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s		0-2' Soil Fill SAND, some silt and gravel
5		2	s/s	6 10	5-7 Brown fine SAND and CLAY, trace
				22	of gravel plastic, moist
					.8' Rec.
10		3	s/s	38 38	10-11.1' Brown fine SAND, a little gravel and
				50/ .1	clay. damp, dense
					11.1' auger refusal in rock
					water at 10.1 in 30 minutes
			C		11.3-12.8' Rock coring 1.5' Rec
15					RQD .6' Weathered boulder
			s/s	17 25	13-14.5' Grey brown SAND, some clay
				30	and silt, a little gravel - moist; dense
				30 65 41	18-19.5' Brown SAND, some clay, a little
20					gravel, moist, dense. .8' Rec.

* ASTM D1586

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-5 OWNER: USAF

LOCATION: ADDRESS: Duluth

TOTAL DEPTH

SURFACE ELEVATION: WATER LEVEL:

DRILLING COMPANY: DRILLING METHOD: DATE DRILLED:

DRILLER: HELPER:

LOG BY:

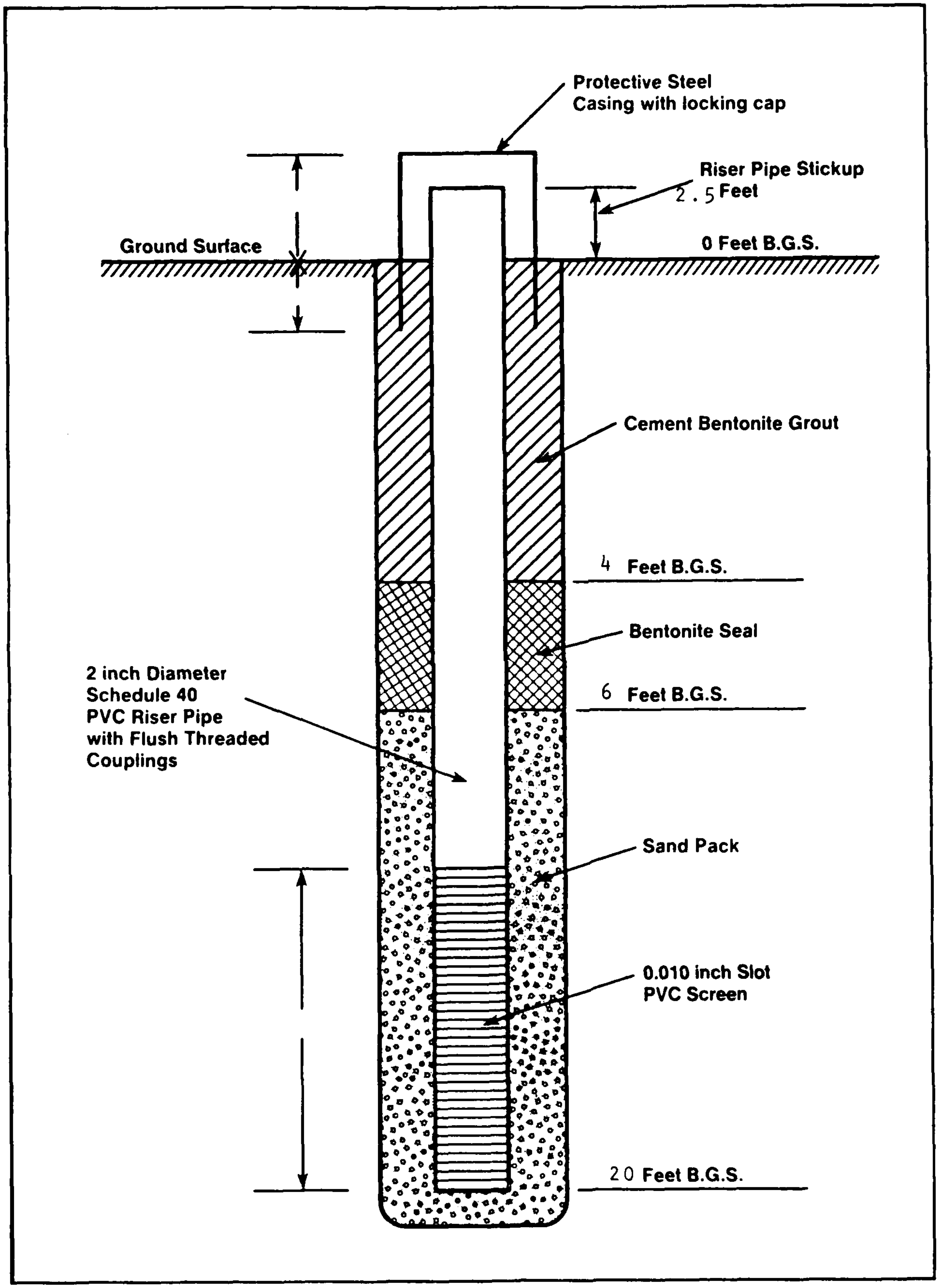
SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
					Well Construction
					10-20' 2" diam. PVC screen .010" slot
					0-10' 2" diam. PVC well pipe
					6-20' sand pack
					4-6' bentonite pellets
					0-4' cement/bentonite grout
					Explosimeter: No Response

* ASTM D1586

SHEET ___ OF ___



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-5

WESTON

DRILLING LOG

WELL NUMBER: MW6 OWNER: USAF

LOCATION: Fire Training Area 1 ADDRESS: Duluth

TOTAL DEPTH 17'

SURFACE ELEVATION: WATER LEVEL: 5'

DRILLING COMPANY: Soil Exp. DRILLING METHOD: Auger DATE DRILLED: 10/27

DRILLER: GL HELPER: MC

LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	1/2	0-2' SAND and GRAVEL Fill.
				5/8	Rec 1.25'
		2	s/s	19 30	5-7' Red brown med-coarse SAND
5				28	some gravel. trace of clay, moist
					Rec. 0.6'
		3	s/s	10/22	10-11.5' No recovery
10			s/s	15/10	11.5-12.5' Br. Fine SAND, some silt and gravel
				25	Rec. 1.0' dense, moist
		4	s/s	23 100/	15-16' Brown fine SAND and SILT, a little
15				.7	angular gravel. moist
					Rock at 17.4', auger refusal
					17.4' end of boring
20					

* ASTM D1586

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW6 OWNER USAF

LOCATION: ADDRESS: Duluth

TOTAL DEPTH

SURFACE ELEVATION: WATER LEVEL:

DRILLING COMPANY: DRILLING METHOD: DATE DRILLED:

DRILLER: HELPER:

LOG BY:

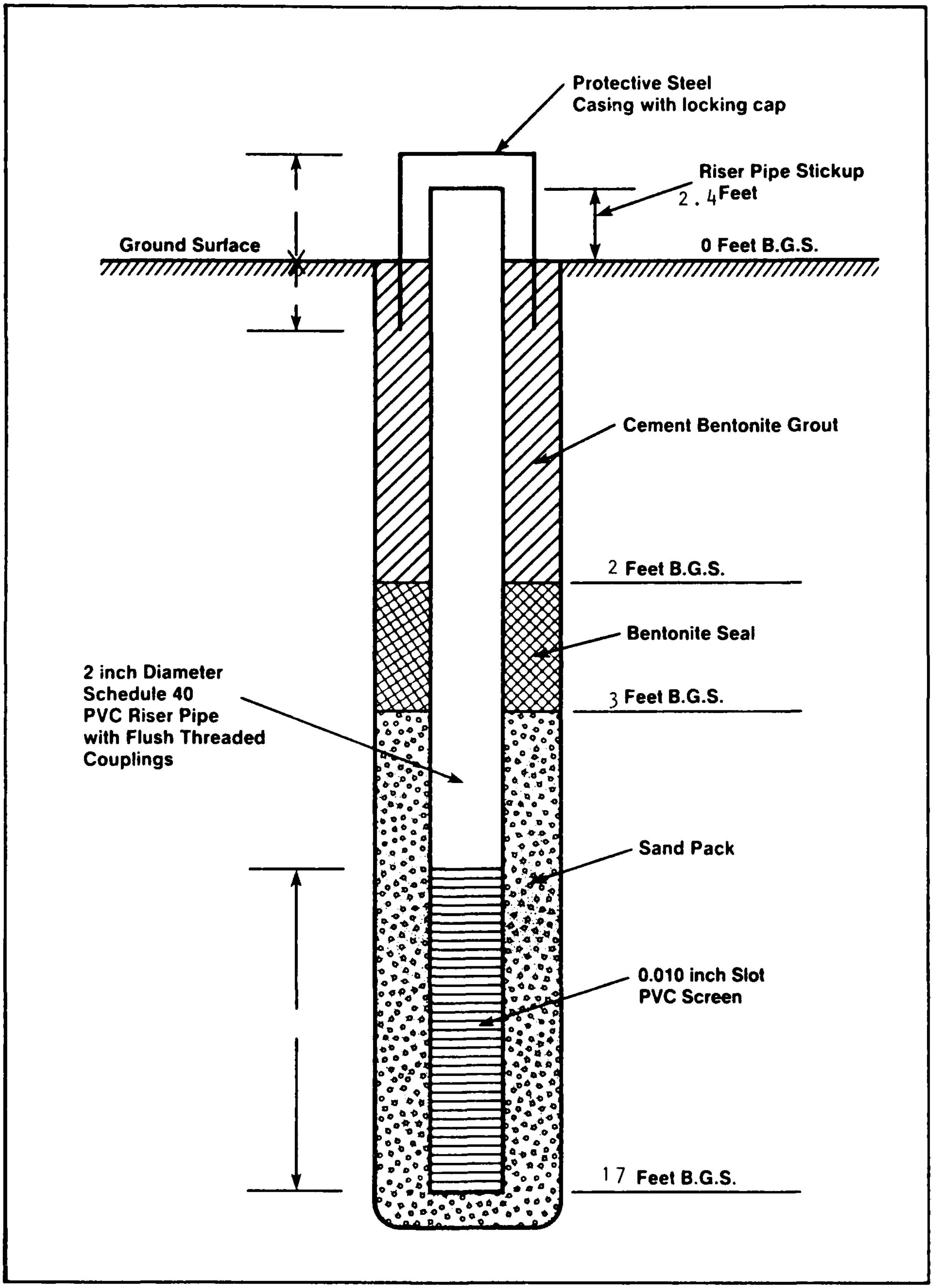
SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
					Well Construction
					7-17' 2" diam PVC screen .010" slot
					0-7' 2" diam PVC riser pipe
					3-17' sand pack
					2-3' bentonite pellets
					0-2' cement bentonite grout
					"Explosimeter: No Response"

* A S T M D1586

SHEET ___ OF ___



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-6

WESTON DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: MW 7
OWNER: USAF
LOCATION: Fire Training Area 1
ADDRESS: Duluth AFB
TOTAL DEPTH: 20'
SURFACE ELEVATION:
WATER LEVEL: 3'
DRILLING COMPANY: Soil Exp.
DRILLING METHOD: Auger
DATE DRILLED: 10/27/83
DRILLER: GL
HELPER: ML
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	3 12 17 17	0-1.5' Organic Top Soil and fill. Rec .5'
5		2	s/s	7 11 14 18	5-7' Brown fine - Med SAND and CLAY overlying brown fine SAND and SILT, Damp Rec - 1.25
10		3	s/s	25 100/.8	10-11.3' Brown fine-med SAND, a little gravel and silt. moist. .25' Rec.
15		4		18 38 38	15-17 Grey brown SAND and GRAVEL, a little silt. dense. damp. 1.3' Rec.
20		5		35 35 34	20-21.5 same as above. Wet .9' Rec.

*ASTM D1586

SHEET 1 OF 2

WESTON

DESIGNERS CONSULTANTS

DRILLING LOG

WELL NUMBER: MW-7

OWNER:

LOCATION: F

ADDRESS: Duluth

TOTAL DEPTH

SURFACE ELEVATION:

WATER LEVEL:

DRILLING COMPANY:

DRILLING METHOD:

DATE DRILLED:

DRILLER:

HELPER:

LOG BY:

SKETCH MAP

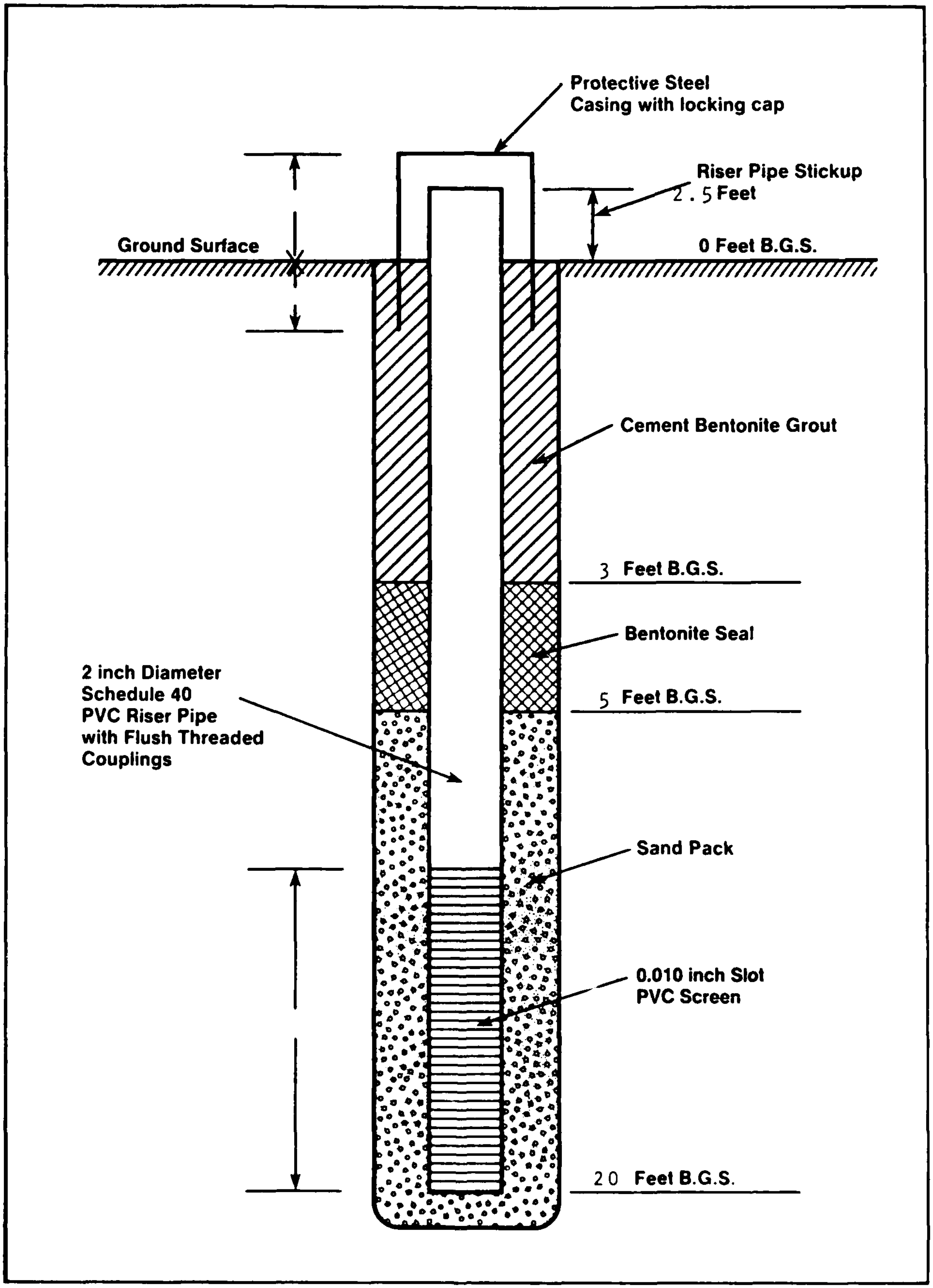
NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
					Well Construction
					10'-20' 2" diam. PVC screen .010" slot
					0-10' 2" diam. PVC riser pipe
					5-20' gravel pack
					3-5' bentonite pellets
					0-3' cement/bentonite grout
					"Explosimeter: No Response"

* ASTM D1586

SHEET ___ OF ___

WESTON



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-7

WESTON

SKETCH MAP

NOTES:

DRILLING LOG

WELL NUMBER TB-4/MW8 OWNER USAF

LOCATION: TANK FARM ADDRESS Duluth

TOTAL DEPTH 15'

SURFACE ELEVATION ______ WATER LEVEL: 4'

DRILLING COMPANY Soil Exp. DRILLING METHOD Auger DATE DRILLED 10/24/83

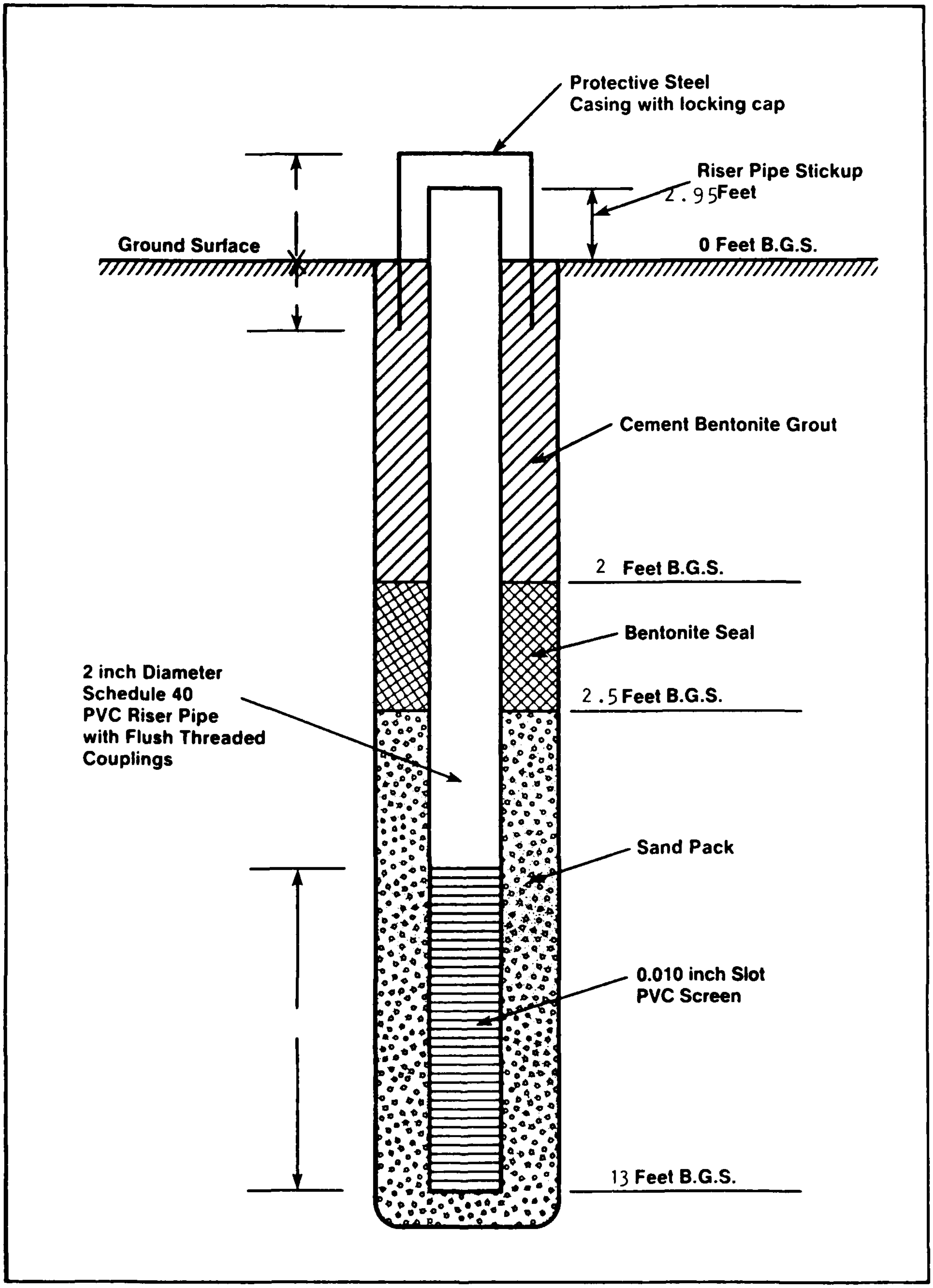
DRILLER: LA HELPER: DS

LOG BY RCJ

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1		4/5	0-2' Red-brown med. SAND, trace clay & gravel
				5/5	.85 Rec.
		2		3/3	2-4' Red brown med coarse sand, trace gravel.
				5/8	.9' Rec.
5		3		4/5	4-6' No recovery, probably cohesionless sand.
				4/4	
		4		1/2	6-8' Red brown med. sand, a little clay, 1.5' Rec.
				1/1	Grey clay, .35' Rec., Wet.
					End of Boring
10					
					10/24/83 - Installed temporary PUC well point.
					10/28/83 - Removed well point and extended boring
					to 15' to install permanent monitoring well
					MW8.

*A.S.T.M. D1586

SHEET ____ OF ____



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-8

WESTON

DRILLING LOG

WELL NUMBER TB-12/MW-9 OWNER USAF
LOCATION Tank Farm ADDRESS Duluth AFB

TOTAL DEPTH 10'
SURFACE ELEVATION: WATER LEVEL: 7'
DRILLING COMPANY: Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25/83
DRILLER: LA HELPER: DS

LOG BY: RCJ

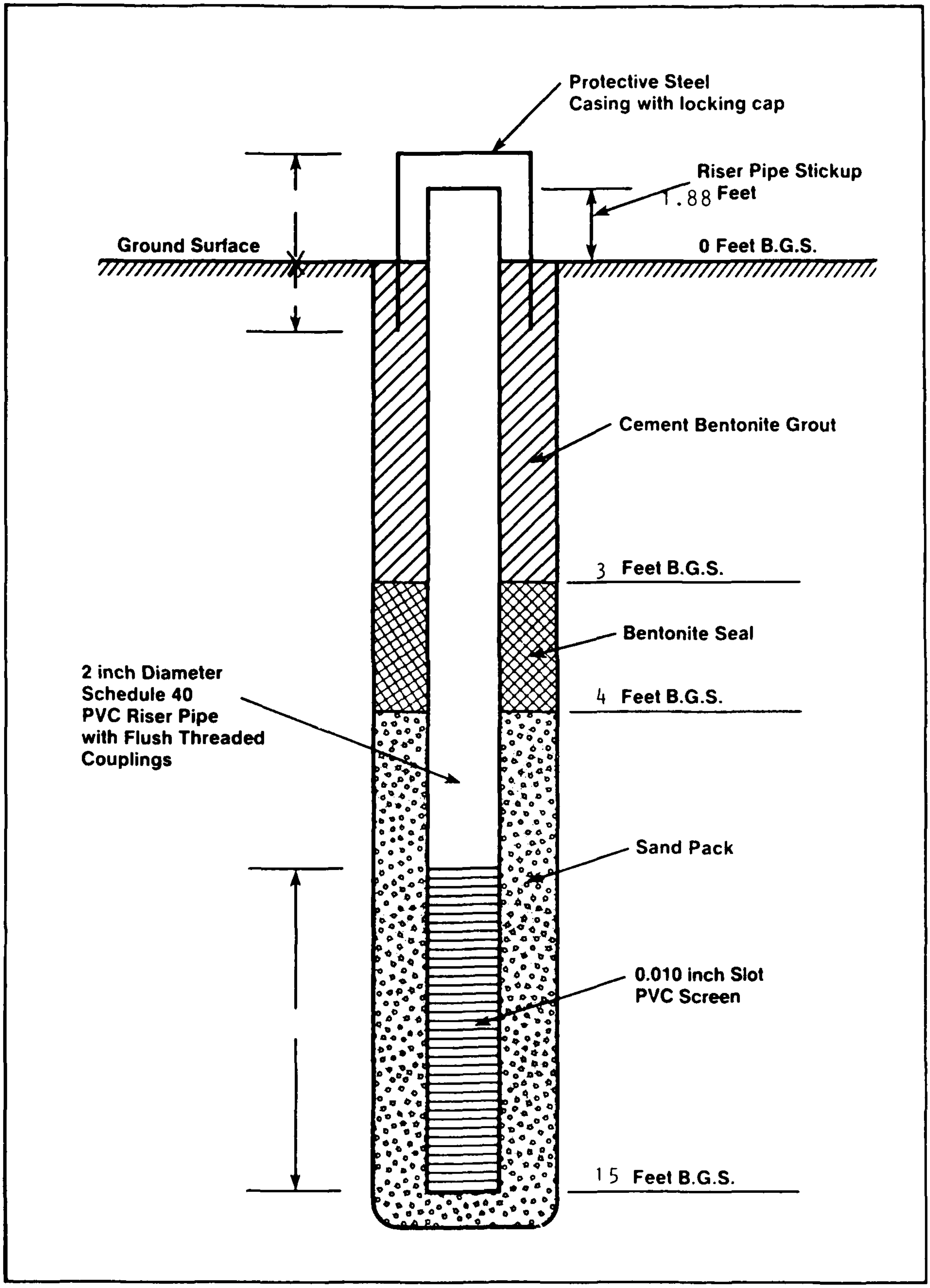
SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	5 10	0-2' Med brown-red med.-coarse SAND Rec: .5'
				7 5	
		2	s/s	4 4	2-4' Med brown red med SAND w/ some clay, Rec: .85'
				3 3	
		3	s/s	4 4	4-6' No recovery, rock in samples
5				2 2	
		4	s/s	4 4	6-8' Med Red/brown CLAY with sand Rec: .15'
				3 4	
		5	s/s	2 4	8-10' Med brown sticky CLAY, tr gravel and sand, moist
10		6	s/s	4 8	Rec: 1.2'
					10/28/83 - Removed temporary 2" PVC point, augered to 13'
					11-13 Dark brown SILT and CLAY
					Set temporary 2" PVC point at 10'
					Installed permanent well MW-9 on 10/28.

*ASTM D1586

SHEET ___ OF ___



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-9

WESTON

DRILLING LOG

SKETCH MAP

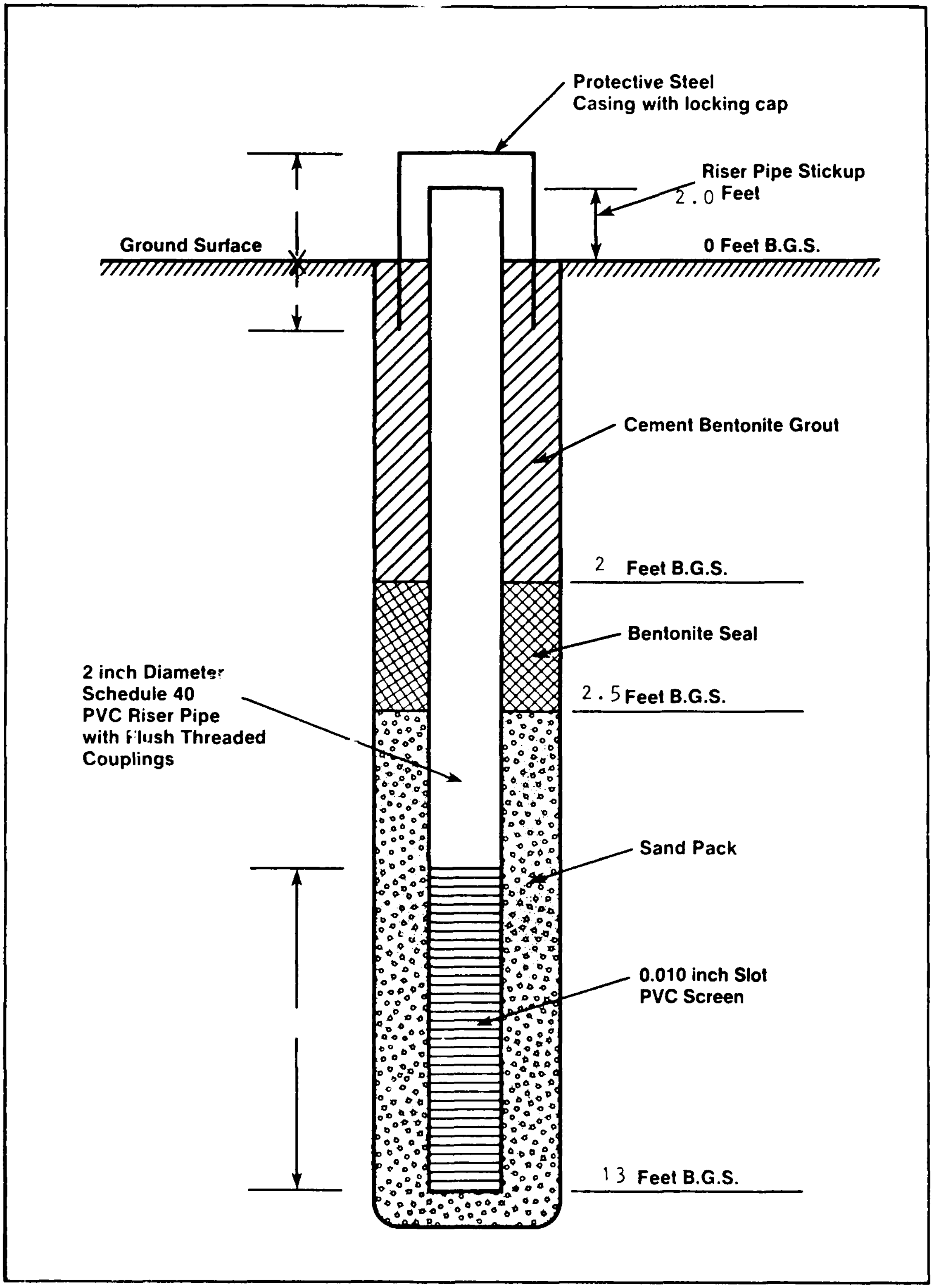
WELL NUMBER TB-11/MW-10 OWNER USAF
LOCATION Tank Farm ADDRESS Duluth
TOTAL DEPTH 6'
SURFACE ELEVATION: WATER LEVEL: 4'
DRILLING COMPANY Soil Exploration DRILLING METHOD: Auger DATE DRILLED: 10/25/83
DRILLER: LA HELPER: DS
LOG BY RCB

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	s/s	3 7 6 6	0-2' Med. brown Sand and GRAVEL, some organic silt Rec:9"
		2	s/s	2 4 5 7	2-4' Med. brown/red Sand and Gravel, ..c: 6"
5		3	s/s	2 3 3 6	4-6' Red/brown SAND with silt, dark brown silt and sand, Rec.: 17"
					10/28/83 Removed temporary 2" PVC point, augered to 13'.
					10/27 Installed temporary 2" PVC well point
10					10/28 Removed well point and augered to 13 feet to install permanent well MW-10. (See well construction log end of boring 13'.

*ASTM D1586

SHEET ____ OF ____



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-10

WESTON

DRILLING LOG

SKETCH MAP

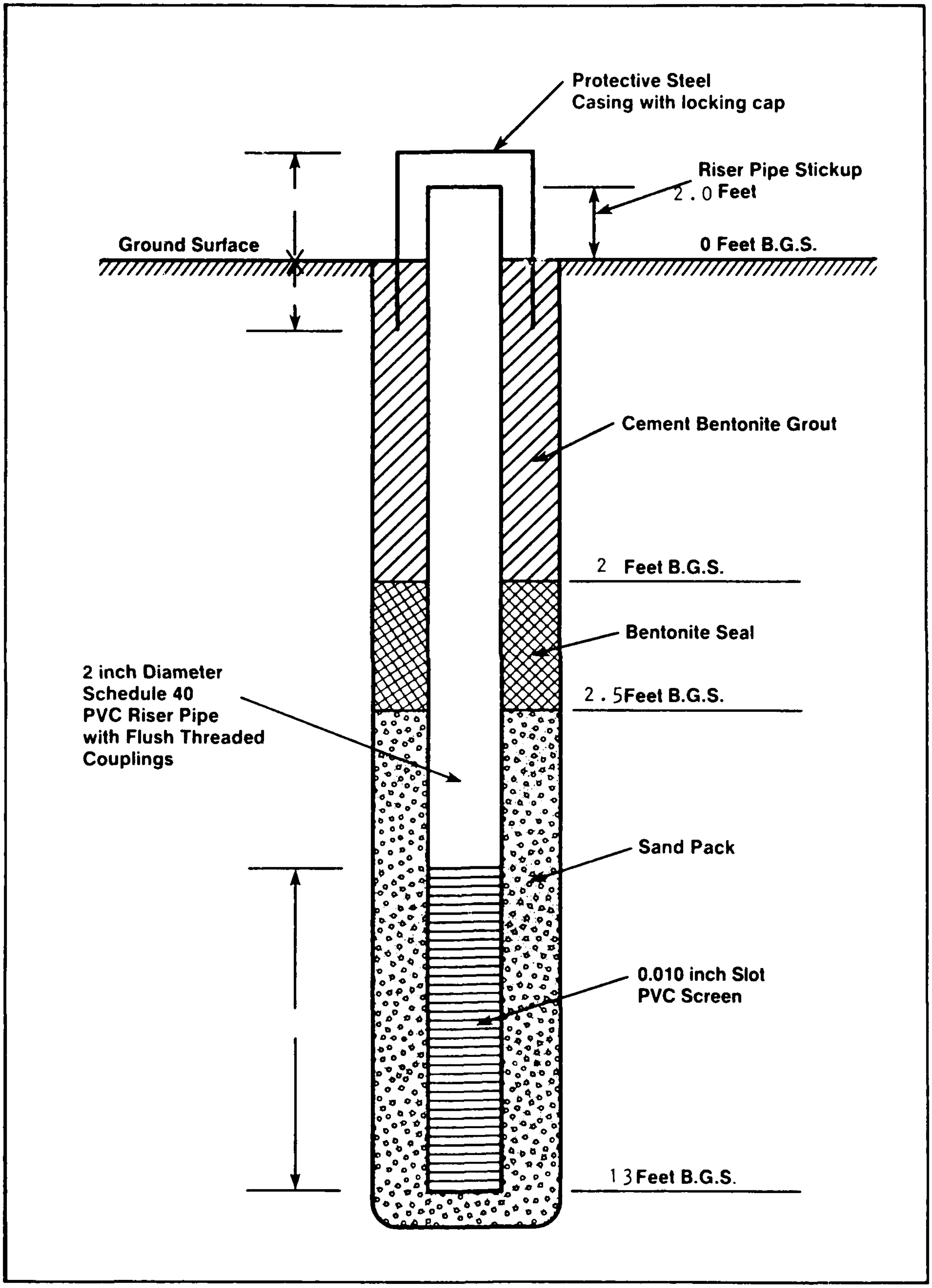
WELL NUMBER: TB-9/MW-11
OWNER: USAF
LOCATION: Tank Farm
ADDRESS: Duluth
TOTAL DEPTH: 10'
SURFACE ELEVATION:
WATER LEVEL: 9'
DRILLING COMPANY: Soil Exploration
DRILLING METHOD: Auger
DATE DRILLED: 10/25/83
DRILLER: LA
HELPER: DS
LOG BY: RCB

NOTES: MW-11 Replaced TB-9

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)
0		1	S/S	2 4	0-2 Med Red/brn silt and m-c SAND Rec: .4'
				5 4	
		2	S/S	1 13	2-4 Red/brn Sand and CLAY, a little gravel Rec: .4'
				8 8	
		3	S/S	2 2	4-6 Dark brown PEAT, damp Rec: .7'
5				2 3	
		4	S/S	1 2	6-7 Dark brown PEAT with wood chips
		5	S/S	2 4	7-8 Green clay, moist Rec: .7 5'
		6	S/S	2 3	8-10 Lt. brown SILT and CLAY, Med. gray/brown clay
				5 5	with some dark concretions, wet at 9' Rec: 1.1'
10					10/27/83-removed temporary 2" PVC point, augered to 15'
			S/S	5 8	Rec: 1.2' 13-15 Med brown CLAY with some silt, a little gravel
				8 10	end of boring 15'
					10/25 Set temporary 2" PVC well point
					10/27 Removed well point and installed permanent
					monitoring well.
					See construction log for MW-11.

* ASTM D1586

SHEET ___ OF ___



WELL CONSTRUCTION LOG DULUTH, MN
WELL NUMBER MW-11

APPENDIX E

Sampling and Quality Assurance Plans

APPENDIX E

SAMPLING AND QA/QC PLANS

E-1.1 MONITORING WELL PURGING

All groundwater sampling was accomplished after the installed monitoring wells were properly developed and had stabilized for a period of at least two weeks. Prior to collecting samples, each well was purged by pumping a minimum of three volumes of standing water in the well using a Johnson-Keck submersible pump[1]. This ensured that a representative sample of the aquifer is collected during the sampling process. The field procedures used for monitoring well purging included the following guidelines:

1. Prior to placing any equipment into the well, the equipment was scrubbed with Alconox (detergent) solution and rinsed with distilled water.

2. Before purging, the depth to water from the referenced measuring point on the top of the well casing was measured and recorded.

3. The volume of water to be purged based on the amount of standing water in the well casing was calculated.

4. The well was purged by pumping, removing at least three times the calculated volume of standing water in the well casing.

5. The pump was disconnected and removed from the well. The equipment was decontaminated by scrubbing with Alconox and flushed with deionized water.

6. The protective caps were secured.

E-1.2 MONITOR WELL SAMPLE COLLECTION

Groundwater sampling was directed toward the detection of:

1. Nitrates
2. Lead

---

[1]A 1.5-inch diameter stainless steel, screw-lift type pump. Capable of a steady flow of around one gpm. A Teflon discharge hose was used.

3. Total Organic Carbon (TOC)
4. Oil and Grease
5. Total Organic Halogens (TOX)

All required sample containers were prepared by WESTON laboratories in accordance with standard EPA procedures and protocols.

After the wells were purged, sampling consisted of the following steps:

1. Each sample container was gently filled from the pump line taking care to avoid aeration and turbulence in the sample water. All samples taken during this sampling were single phase (water).

2. Appropriate containers were filled according to analytical parameter. The containers used were:

   - Oil and Grease: One liter amber glass bottles preserved with H_2SO_4

   - TOC: 40 ml septum vials preserved with HCL

   - TOX: 250 ml septum seal glass bottles preserved with sulfuric acid

   - Metals (Lead): 1 liter plastic bottle preserved with nitric acid

   - Nitrate: 1 liter amber glass bottle

   All containers had Teflon-lined caps.

3. Grab samples were taken for immediate analyses in the field for pH, temperature and specific conductance

4. The sample containers were wrapped in packaging material and placed in a thermal chest packed with enough ice to insure cooling to $4^{\circ}C$.

E-1.3 Surface Water and Soil Sample Collection

The methods for taking samples of surface waters, pond bottom sediments and soil boring samples are described in the text (Section 3.2.2.4 - DPDO Soil Borings, and Section 3.2.3.1 - Goose Missile Site Pond). Sample handling and preservations were the same as those used for groundwater samples with the following additional parameters:

1. Volatile Organics in Soils: 40 ml crimped top serum vials with Teflon-lined lids

2. Pesticides in Water and Soils: One liter brown glass bottles

3. Oil and Grease in Soils: 500 ml brown glass bottles. Preserved with H_2SO_4

E-2.0 QUALITY ASSURANCE PLAN

WESTON Analytical Services enforces a rigid QA/QC program toward maintenance of validity and reliability of all analytical data. The Laboratory QA/QC Manual (Table of Contents thereof is Attachment No. 1 to this appendix) outlines the specifics of the QA/QC plan. This plan is patterned after the EPA Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA-600/4-79-019, March 1979), augmented by general applicable experience and interaction with the QA/QC plan of the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). All methods and procedures followed by WESTOn are either USEPA or ASTM-approved. Any variations from such procedures, regardless of cause, are documented by the responsible analyst(s) and are documentable, and, literature-traceable. A general review of this QA/QC plan is in the following paragraphs.

Although specific QA/QC measures for each method are designated in WESTON's Laboratory Quality Assurance Manual, the general QA/QC program normally includes:

- EPA-acceptable sample preparation and analytical methods.

- Instrument calibration via use of Standard Analytical Reference Materials (SARMS).

- Regular equipment maintenance and servicing.

- Use of SARMS and QA/QC samples (spikes, laboratory blanks, replicates, and splits) to ascertain overall precision.
- Statistical evaluation of data to delineate acceptable limits.
- Documentation of system/operator performance.
- Suitable chain-of-custody procedures.
- Maintenance and archiving of all records, charts, and logs generated in the above.
- Proper reporting.

Acceptable analyses at WESTON's Analytical Laboratory Services include, but are not limited to, the above.

In general, WESTON's QA/QC sequence follows the following diagram (Figure F-1). Documentation (as available from instrument recordings and technicians' notebooks) is sufficient to validate each step in the sequence.

E.2.2 CONTAINER PREPARATION

Another consideration in this, or any, analytical project is that of sample container preparation. Accordingly, all appropriate sample bottles shall be cleaned in a manner mandated by the U.S. EPA to insure maximal cleanliness (and minimal contamination) before the containers go to the field. Sufficient bottles to accommodate both laboratory and field blank requirements will be preferred in a single batch mode for each monthly sampling requirement.

E.2.3 VERIFICATION/VALIDATION

In the laboratory, the analytical scheme begins with initial verification, which is comprised of:

- Lab Blanks - To insure that no background level of specific analytes is introduced by laboratory procedures.
- Standard Analytical Reference Materials (SARMS) - To determine the accuracy and precision of procedures.

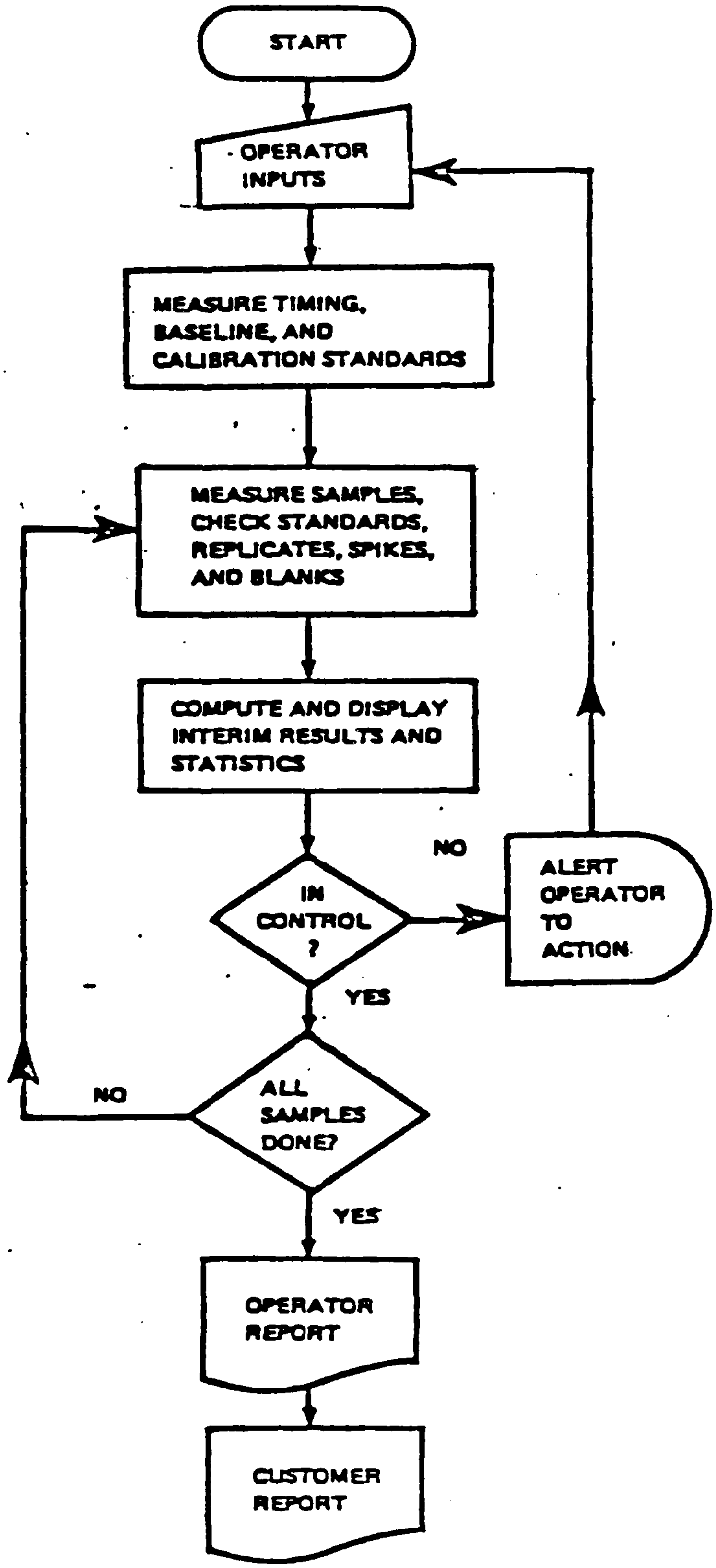


Figure E-1: Flow Chart of the Sequence of Events during a Controlled Series of Laboratory Measurements.

o Spikes - To determine the percent recovery of analyte(s).

If the laboratory QA/QC program is extended to the field, it includes a fifth item:

- o Field Blanks - To provide a check on contamination of containers and/or preservatives and to establish "practical" detection limits.

WESTON has used all of the above in this project. All data resulting from these verification media have been archived for future reference, retrieval, or processing.

E.2.4 DATA HANDLING - LABORATORY

Use of any analytical data should be preceded by an assessment of its quality. The assessment should be based on accuracy, precision, completeness, representativeness, and comparability. These criteria are, in turn, assessed as follows:

- o Accuracy - Is it acceptable for the planned use? QA/QC shall measure the accuracy of all data.
- o Precision - Is it acceptable for the planned use? QA/QC shall reflect the reproducibility of the measurements.
- o Completeness - Are the data sufficient for the planned use? QA/QC shall identify the quantity of data needed to match the goals.
- o Representativeness -Do the data accurately reflect actual site conditions, sampling procedures, and analytical method? QA/QC shall ensure this.
- o Comparability - Is the report self-consistent in format, units, and standardization of methods used to generate it? QA/QC shall ensure this.

Additionally, statistical methods outlined in the QA/QC program have been applicable to data evaluation.

The Laboratory Supervisor and the Laboratory QA/QC Officer have been responsible for the evaluation of the above criteria and for enforcement of analytical protocols that

will necessarily lead to acceptable data quality. The signature of the Supervisor and QA/QC Officer accompany each laboratory analytical report and serve to ensure the overall validity of the reported data.

E.2.5 SAMPLE PLAN/LOG

Normal protocol demands client-and /or site-specific logging of all sample batches delivered to WESTON. Basic information -- such as client name, address, etc.; client phone number; reporting/invoicing instructions; site descriptions; and parameter-specifications and total requirements -- is initiated here. Additionally, sample storage/disposal instructions as well as turnaround requirements and sample collection requirements are addressed at this point.

The appropriate number of method blanks is also logged at this point, and in-house chain-of-custody documentation is initiated here.

E.2.6 SAMPLE RESULTS

WESTON's analytical protocols generally require five-point calibration curve plus a reagent blank s the basis for quantification analytes from a linear calibration curve. (A three-point plus blank curve vs. the original five point one is acceptable if it falls within the QA/QC requirements of ± 3 standard deviation of the original curve.) Linear regression analysis is then performed. Method- and detection limit-specific data are accessed for quantitation and report-writing from each such data set. For reporting accuracy, the algorithm

$$\frac{\begin{matrix}\text{Linear-Regressed} \\ \text{Raw Concentration} \\ \text{from Calibration Curve}\end{matrix} \quad \begin{matrix}\text{Solid Sample} \\ \text{Extract Volume} \\ \text{If Solid}\end{matrix} \quad \begin{matrix}\text{Concentration} \\ \text{or} \\ \text{Dilution Factor}\end{matrix}}{\begin{matrix}\text{Solid Sample} \\ \text{Mass If Solid}\end{matrix} \quad \begin{matrix}\text{Fraction} \\ \text{Solids If Solid}\end{matrix}} = \begin{matrix}\text{Final} \\ \text{Concen-} \\ \text{tration}\end{matrix}$$

is used for all quantitations. (All such algorithm input data are archived for long-term storage.) Detection limits for solids are generated on a per-sample basis and calculated by replacing "LINEAR-REGRESSED RAW CONCENTRATION FROM CALIBRATION CURVE" with "DETECTION LIMIT OF ANALYTE IN LIQUID MATRIX" in the above equation.

WESTON

E.2.7 CHAIN-OF-CUSTODY

Since they document the history of samples, chain-of-custody procedures are a crucial part of a sampling/analysis program. Chain-of-custody documentation enables identification and tracking of a sample from collection to analysis to reporting.

WESTON's chain-of-custody program necessitates the use of EPA-approved sample labels, secure custody, and attendant recordkeeping. Depending on the client's requirements, WESTON also offers container sealing during unattended transportation of samples.

In essence, WESTON considers a sample in custody if it: is in a WESTON employee's physical possession; it is in view of that WESTON employee; is secured by that WESTON employee to prevent tampering; or is secured by that WESTON employee in an area that is restricted to authorized personnel.

Each time a sample is relinquished from one analyst to another or from one major location to another, WESTON's analytical personnel are required to make appropriate entries. Personnel-specific initials are used as identifiers of analysts, as are location codes for various locations (refrigerators, extraction areas, analytical areas, etc.) within the laboratory. Each transaction for each sample is accompanied by a specific reason for transfer. Chain-of-custody documentation is given in Appendix F.

E.2.8 QA/QC OFFICER

Toward maintenance of a rigid, credible QA/QC regimen, WESTON Analytical Services maintains a full-time, in-house QA/QC officer who retains independent authority to declare out-of-control situations, thereby precluding reporting of unacceptable data. The QA/QC officer has been available, as needed, on the project.

APPENDIX F

Sample Chain-of-Custody Documentation

DULUTH AFIS
~~DULUTH~~

0620-05-25

RECEIVED

PRIORITY/HAZARD

SUBMITTED BY [signature]

MISC. CCI 646

	SAMPLE DESCRIPTION	DATE COLLECTED	PA	PA	PA	PA	PA	PA	PA
9782	LOC - 1 H_2O & SOIL GOOSE CREEK	11/16	Pest	TOC	TOx	Pest			
9783	LOC - 2 " "		H_2O	H_2O	H_2O	Soil			
9784	LOC - 3 " "		✓	✓	✓	✓			
9785	LOC - 4 " "		✓	✓	✓	✓			
9786	LOC - 5 " " SOIL ONLY		X	X	X	✓			
9787	LOC - 6 "		✓	✓	✓	✓			
9788	LOC - 7 " "		✓	✓	✓	✓			
9789	LOC - 8 " "		✓	✓	✓	✓			
9790	LOC - 9 " "		✓	✓	✓	✓			
10.	[illegible]		✓	✓	✓	✓			
9791	LOC - 10 " SOIL ONLY		X	X	X	✓			
9792	LOC - 11 SOIL ONLY		X	X	X	✓			
9793	LOC - 8 - D H_2O - NO SOIL	✓	✓	✓	✓	X			
14.									
15.	~~H_2O Fire Training Area~~	~~11/16~~	~~TOC~~	~~TOx~~	~~Nitrates~~	~~VOA~~			
16.	~~MW-2~~								
17.	~~MW-3~~								
18.	~~MW-4~~								
19.	~~MW-5~~								
20.	~~MW-6~~								
21.	~~MW-7P~~								
22.									
23.									
24.									

AD-A148 318 INSTALLATION RESTORATINN PROGRAM PHASE II STAGE 1 3/3
PROBLEM CONFIRMATION STUDY DULUTH INTERNATIONAL AIRPORT
DULUTH MINNESOTA(U) WESTON (ROY F) INC WEST CHESTER PA
UNCLASSIFIED OCT 84 F/G 13/2 NL

END
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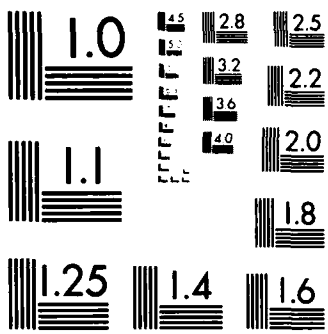

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CHAIN OF CUSTODY

1. RFW # ____________________

2. No. of bottles on this sheet:
   - 40 ml ______
   - 100 ml ______
   - 250 ml ______
   - 500 ml ______
   - 1000 ml ______
   - Total ______

3. Sampled by: ____________________

4. Samples preserved and prepared according to S.O.P.: ____________________ Initials

Relinquished	Received by	Time	Date	Reason for Change of Custody
	Patricia K. Dalano		11/18/84	Analysis

COMMENTS: ____________________

CLIENT Duluth AFB

PRIORITY/HAZARD

WO#/PO# 0628-05-28

SUBMITTED BY

DATE RECEIVED 1/6

MISC: 003 711

FW#	SAMPLE DESCRIPTION	DATE COLLECTED	PA	PA	PA	PA	PA	PA	PA
1-711-0010	MW-1	1/5	1/6 by IR						
0020	MW-2								
0030	MW-3								
0040	MW-4								
0050	MW-5								
6. 0060	MW-5 Dup								
0070	MW-6								
0080	MW-7								
9.	~~[illegible]~~								
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									
18.									
19.									
20.									
21.									
22.									
23.									
24.									
25.									

CHAIN OF CUSTODY

1. RFW # ______________________________

2. No. of bottles on this sheet:
   - 40 ml ______
   - 100 ml ______
   - 250 ml ______
   - 500 ml ______
   - 1000 ml ______
   - Total ______

3. Sampled by: ______________________________

4. Samples preserved and prepared according to S.O.P.: ______________
   Initials

Relinquished	Received by	Time	Date	Reason for Change of Custody
	[signature]		1/6/84	Analysis

COMMENTS: ______________________________

APPENDIX G

Standard Laboratory Analytical Protocols

APPENDIX G

ANALYTE	DETECTION LIMIT	METHOD
o Total Organic Halogen (TOX)	5 µg/l	EPA Method 9020
o Total Organic Carbon (TOC)	1 mg/l	EPA Method 415.1
o Oil and Grease	.1 mg/l	IR EPA Method 412.3
o Volatile Organic Compounds (VOC)	(specified by compound in method)	EPA Methods 601 and 602
o Lead (Soluble)	20 µg/l	EPA Method 239.2
o Pesticides:		
aldrin	.02 µg/l	EPA Method 608
DDT isomer	.02 µg/l	
dieldrin	.02 µg/l	
endrin	.02 µg/l	
heptachlor	.02 µg/l	
lindane	.01 µg/l	
methoxychlor	.02 µg/l	
diazinon	.02 µg/l	
malathion	.10 µg/l	
parathion	.02 µg/l	
2,4D	.06 µg/l	
2,4,5T	.06 µg/l	
2,4,5T (Silvex)	.02 µg/l	

Oil and Grease

Scope:

The method is applicable to the determination of oil and grease in water.

Safety Precautions

Observe all standard laboratory safety procedures.

Principle

Oil and grease is extracted from water by intimate contact with 1,1,2-trichloro-1,2,2-trifluoroethane.

Interference

Trichlorotrifluoroethane has the ability to dissolve not only oil and grease but also other organic substances.

Sensitivity, Precision and Accuracy

The precision and accuracy have not been determined.

Apparatus

1. Infrared spectrophotometer, double beam, recording.
2. Cells, near-infrared silica.
3. Separatory funnel, 2 liter, with TFE stopcock.
4. Rotor evaporator and heating baths.
5. Grease-free cotton. (Glass wool)

Reagents

1. Hydrochloric acid, HCL, concentrate.
2. Granular sodium sulphate.
3. 1,1,2-trichloro-1,2,2-trifluoroethane.

Procedure

1. Acidify to pH 2.0. Add 2 or 3 drops concentrate HCL.
2. Transfer sample to a separatory funnel.
3. Rinse sample bottle with 100 ml of freon and add solvent washings to separatory funnel and extract.

Oil and Grease

Scope:

The method is applicable to the determination of oil and grease in soil and sludges.

Safety Precautions

Observe all standard laboratory safety procedures.

Principle

Oil and grease is extracted from soil by intimate contact with 1,1,2 - trichloro - 1,2,2 - trifluoroethane.

Interference

Trichlorotrifluoroethane has the ability to dissolve not only oil and grease but also other organic substances.

Sensitivity, Precision and Accuracy

The precision and accuracy have not been determined.

Apparatus

1. Infrared spectrophotometer, double beam, recording.
2. Cells, near-infrared silica.
3. Extraction apparatus, Soxhlet.
4. Extraction thimble, paper.
5. Rotor evaporator and heating baths.
6. Grease-free cotton. (glass wool)

Reagents

1. Hydrochloric acid, HCl, concentrate.
2. Magnesium sulfate monohydrate.
3. 1,1,2 - Trichloro - 1,2,2 - trifluoroethane.

Procedure

1. Weigh out 20 ± 0.5 g of sample in a 150 mL beaker.
2. Acidify to pH 2.0. Add 2 or 3 drops 50% H_2SO_4.

3. Add 20g, Mg $SO_4 \cdot H_2O$ and mix uniformly.

4. Transfer to a paper extraction thimble (size 33 x 94) and place glass wool plug in top of thimble.

5. Extract in a Soxhlet apparatus, using 150 mL trichloro-trifluoroethane, at a rate of 20 cycles/hr. for 3 hours.

6. Turn off heat to Soxhlet apparatus, take off condensor, and let trichlorofluoroethane evaporate until sample extract and volume around extraction thimble is less than 100 mL.

   Pour sample extract from boiling flask through glass wool into a 100 mL clean volumetric flask.

   a) Use trichlorofluoroethane Soxhlet extractor to rinse boiling flask. (Because of low boiling point of trichlorofluoroethane compared to O&G, roto evaporator is not necessary.)

   b) The glass wool removes water and/or solid Mg SO_4/sample that may end up in trichlorofluoroethane extract.

7. For quantitation use an infrared spectrophotometer.

8. Calculations:

$$\text{oil/grease in } \mu g/g = \left(\frac{\mu g}{mL}\right) \times \frac{100 \text{ mL}}{\text{g of sample used}}$$

where:

1) $\frac{\mu g}{mL}$ is obtained from the oil/grease IR standard curve

2) $ppm = \frac{\mu g}{g}$ or $\frac{mg}{kg}$ or $\frac{\mu g}{mL}$ or $\frac{mg}{L}$

Reference: Methods for the Examination of Water and Waste Water, 15th Edition, 1980.

4. Extract twice more with two 100 ml portions. Filter freon extracts through 25 grams NA_2SO_4.

5. Rotovap combined extracts to 5 ml.

6. Transfer to a 10 ml volumetric and bring to volume.

7. For quantitation, use an infrared spectrophotometer.

8. Calculations:

$$\text{Oil/grease in ug/ml} = \left(\frac{\text{ug}}{\text{ml}}\right) \times \frac{10\ \text{ml}}{1000\ \text{ml}}$$

Where 1) $\frac{\text{ug}}{\text{ml}}$ is obtained from the oil/grease IR standard.

2) $\text{ppm} = \frac{\text{ug}}{\text{g}}$ or $\frac{\text{mg}}{\text{kg}}$ or $\frac{\text{ug}}{\text{ml}}$ or $\frac{\text{mg}}{\text{l}}$

Reference: Methods For The Examination Of Water and Wastewater, 15th Edition, 1980.

APPENDIX H

Raw Water Quality Data

TO: ______________________

DATA SUMMARY SHEET

Date(s) Samples Collected 11/16

W.O/P.O. No. 0628-05-25 Client Duluth AFB

RFW No.	B.S. RFW #	Sample Description	Pest H2O	TOC mg/l	TOX ug/l	Pest Soil			
9782		Loc 1 Above Ck.		10.9	12.6				
9783		Loc 2		8.8	11.0				
9784		3		6.6	13.9				
9785		4		9.7	5.9				
9786		5							
9787		6	see attached	11.5	24.1	see attached			
9788		7		11.0	16.5				
9789		8		8.85	2.7				
9790		9		10.7	29.1				
9791		10							
9792		11							
9793		8D		8.85	[illegible]				

Signed [signature] Date 7/13/84

Q. A. Officer

Duluth Data - Sediments

		9782	9783	9784	9785	9786	9787	9788	9789	9790	9791	9792
Aldrin		<10	—									
γ BHC		<10										
Heptachlor		<10										
Heptachlor	Epoxide	<10	—									
		<10	—									
		<10	—									
DDT		<10	—									
pp methoxychlor		<10	—									
Endrin		<10	—									
dieldrin		<10										
DDE		<10	—									
DDD		139	1'2	92	<100	1.2	215	132	16	56	<1.0	<1.0
PCB												
Aroclor	1260	450	74	360	1200	17	1300	320	82	160	<10	<10

All Results in ppb

1/30/84 George [illegible]

[illegible] 7/13/84

Duluth Data - Water Samples

	9782	9783	9784	9785	9787	9788	9789	9790	9793
Aldrin	<0.1								
γ BHC	<0.1								
Heptachlor	<0.1								
Heptachlor Epoxide	<0.1								
DDE	<0.1								
DDD	<0.1				0.18				
DDT	<0.1								
p,p' methoxychlor	<0.1								
endrin	<0.1								
dieldrin	<0.1								
PCB									
Aroclor 1260	<0.1				0.2	<0.1			

All results in ppb

1/30/84 George Darcy

[illegible] 7/13/84

TO: [illegible]

DATA SUMMARY SHEET

Date(s) Samples Collected [illegible]

W.O/P.O. No. [illegible] Client [illegible] AFB

RFW No.	B.S. RFW #	Sample Description	mg/L O/G - 12	VOA					
9354	830-559-0010	C-6 0-1	41,800						
9355	830-559-0020	C-6 1-2	13400						
[illegible]	830-559-0030	C-7 0-1	40,000						
[illegible]	40	C-7 1-2	13,100						
[illegible]	50	C-8 0-1	49,500						
[illegible]	60	C-8 1-2	16900						
[illegible]	70	C-9 0-1	7325						
[illegible]	80	C-9 1-2	243						
[illegible]	90	C-10 0-1	194						
9375	100	C-10 1-2	161						
9379	110	C-1 0-1	16,700						
[illegible]	120	C-1 1-2	16,700						
[illegible]	130	C-2 0-1	23400						
[illegible]	140	C-2 1-2	5700						
[illegible]	150	C-3 0-1	23400						
[illegible]	160	C-3 1-2	5600						

[illegible] 7/3/84

Signed ____________ Date ____________

Q. A. Officer

DATA SUMMARY SHEET

Date(s) Samples Collected 11/1

W.O/P.O. No. [illegible]-03-35 Client [illegible] AFB

RFW No.	B.S. RFW #	Sample Description	O&G-IR	VOA					
9344	831-589-0170	C-4 0-1	35,400						
9345	180	C-4 1-2	14,500						
9349	190	C-5 0-1	13400						
9350	200	C-5 1-2	3680						

[illegible] 7/13/84

Signed ____________ Date ____________

Q. A. Officer

TO: ______________________________

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DATA SUMMARY SHEET

Date(s) Samples Collected 11/15

W.O/P.O. No. 0628-05-25 Client Duluth AFB

8312-653-0010->0060

RFW No.	B.S. RFW #	Sample Description	mg/l TOC	mg/l O/G	VOA	ppb Pb	ug/l TOX	mg/l NO_3
9794		W8 Tank	49.3	0.36		2.01 2.5		
9795		W9	70.0	1.46		2.70 3.2		
9796		W10	49.0	49.8		2.80 3.3		
9797		W11	17.0	NF		2.21 2.7		
9798		W10 Dup	70.0	0.47		2.51 3.0		
9799		FB-1	<1	0.37		2.51 3.0		
9800		W1 Fire	25				44.3	0.48
9801		W2	67.5				602.6	0.55
9802		W3	66.2				81.7	0.93
9803		W4	5.6				15.9	0.37
9804		W5	44.6				28.0	0.35
9805		W6	24.6				15.4	0.35
9806		W7	19.0				126.3	0.47
9807		W5 Dup	34.1				6.6	0.32
9808		TP-1		249				
9809		TP-2	140	3240		31.0		

7/3/84

Signed ______________________ Date ______________

Q. A. Officer

DATA SUMMARY SHEET

Date(s) Samples Collected 11-15-83

W.O/P.O. No. 062805-25 Client Duluth AFB

RFW No.	B.S. RFW #	Sample Description	O/G	VOA	TOC	Pb			
9810		DPDO #1 Soil	11,000						
9811		#2 Soil	3470						
9812		Gulley #1	0.50		47.2	5.1			
9813		Gully #2	208		48	6.1			

[illegible signature] 7/13/84

Signed ______________ Date ______________

Q. A. Officer

TO: ______________________

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CC3

DATA SUMMARY SHEET

W.O/P.O. No. 01-28 05-25

Date(s) Samples Collected 1/5/84

Client Duluth AFB

RFW No.	B.S. RFW #	Sample Description	mg/l alkalinity IR						
	8401-711-0010	MW-1	0.19						
	0020	MW-2	0.53						
	0030	MW-3	0.86						
	0040	MW-4	0.42						
	0050	MW-5	0.75						
	0060	MW-5 Dup	0.38						
	0070	MW-6	0.27						
	0080	MW-7	0.81						

[illegible signature]
1/13/84

Signed ______________________ Date ______________
Q. A. Officer

WESTON
DESIGNERS CONSULTANTS

inter-office memorandum

TO: Richard Johnson

DATE: Jan. 25, 1984

FROM: Don H. Baker, III

SUBJECT: Duluth Soils VOA 601/602 Analysis

W. O. No.:

Attached are the results of methods 601/602 VOA analysis on the Duluth Air Force Base soils. All 601/602 parameters not listed in these results can be considered nondetectable at 1.0 ug/kg of dry soil.

DHB:mr

LOT 1

LAB SAMPLE NO.	FIELD SAMPLE DESCRIPTION	PARAMETER	RESULT ug/kg
83-2179	C-2 0-1 ft.	Chloroform	120
		Methylene Chloride	150
		Bromodichloromethane	1
83-2192	C-8 0-1 ft.	Methylene Chloride	180
		Dibromochloromethane	3
		Trichloroethylene	14
83-2183	C-4 0-1 ft.	1,1,1-Trichloroethane	3
		Chloroform	315
		Methylene Chloride	850
		Bromodichloromethane	8
		Tetra chloroethylene	1
		Trichloroethylene	5
83-2189	C-7 0-1 ft.	Chloroform	55
		Trans-1,2-Dichloroethylène	6
		Methylene Chloride	100
83-2197	S-2 #1	1,1,1-Trichloroethane	1
		Chloroform	240
		Trans-1,2-Dichloroethylene	500
		Methylene Chloride	330
		Bromodichloromethane	16
		Trichloroethylene	140
83-2198	S-2 #2	1,1,1-Trichloroethane	1
		Chloroform	220
		Methylene Chloride	335
		Bromodichloromethane	6
		Trichloroethylene	20
Reagent Blank Lot 1		Methylene Chloride	150

LOT 2

LAB SAMPLE NO.	FIELD SAMPLE DESCRIPTION	PARAMETER	RESULT ug/kg
83-2180	C-2,1-2 ft.	Methylene Chloride	55
83-2182	C-3,1-2 ft.	Chloroform	47
		Methylene Chloride	2600
		Tetrachloroethylene	2
83-2184	C-4,1-2 ft.	Chloroform	66
		Methylene Chloride	2200
83-2185	C-5,0-1 ft.	Chloroform	76
		Methylene Chloride	2400
		Trichloroethylene	210
83-2186	C-5,1-2 ft.	Chloroform	48
		Methylene Chloride	1200
		Trichloroethylene	940
83-2187	C-6,0-1 ft.	1,1,1-Trichloroethane	11
		Chloroform	61
		Methylene Chloride	1900
		Tetrachloroethylene	300
		Trichloroethylene	2
83-2188	C-6,1-2 ft.	1,1,1-Trichloroethane	210
		Chloroform	73
		Methylene Chloride	1300
		Tetrachloroethylene	220
83-2190	C-7,1-2 ft.	Chloroform	18
		Methylene Chloride	350
83-2177	C-1,0-1 ft.	1,1,1-Trichloroethane	11
		Chloroform	25
		Methylene Chloride	450
Reagent Blank Lot 2		Methylene Chloride	1100

LOT 3

LAB SAMPLE NO.	FIELD SAMPLE DESCRIPTION	PARAMETER	RESULT ug/kg
83-2193	C-9 0-1 ft.	1,2-Dichloroethane	3
		1,1-Dichloroethane	12
		1,1 Dichloroethylene	32
		Methylene Chloride	1000
		Tetrachloroethylene	1
83-2194	C-9 1-2 ft.	1,2-Dichloroethane	18
		1,1-Dichloroethane	13
		1,1 Dichloroethylene	37
		Methylene Chloride	1100
83-2195	C-10 0-1 ft.	1,2-Dichloroethane	3
		1,1-Dichloroethane	22
		1,1-Dichloroethylene	15
		Methylene Chloride	860
83-2196	C-10 1-2 ft.	1,2-Dichloroethane	3
		1,1-Dichloroethane	7
		1,1-Dichloroethylene	12
		Trans-1,2-Dichloroethylene	14
		Methylene Chloride	740
83-2181	C-3 0-1 ft.	1,1 Dichloroethylene	6
		Methylene Chloride	53
83-2191	C-~~8~~3 0-1 ft.	1,1-Dichloroethylene	15
		Methylene Chloride	24
Reagent Blank Lot 3		Methylene Chloride	1100

END

FILMED

1-85

DTIC